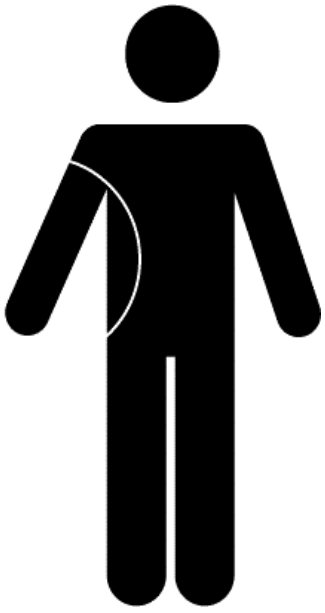
Treatment Recommendations of the 2001 Consensus Panel



HEART AND STROKE FOUNDATION OF ONTARIO

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Foreword

The Heart and Stroke Foundation of Ontario is pleased to provide support to the work of the Consensus Panel on Hemiplegic Arm and Hand.

The Foundation is actively engaged in promoting a coordinated stroke care system across Ontario. One critical component of that system is high quality, effective stroke rehabilitation to reduce disability and handicap. In 1999, the Foundation, in consultation with the Ministry of Health and Long-Term Care, established a consensus panel on stroke rehabilitation. The panel undertook an extensive literature and data review and, with input from stroke survivors, their families and professional caregivers, developed a vision and recommendations for a system of stroke rehabilitation.

One of the panel's recommendations was that the Ministry and the Foundation jointly sponsor an ongoing program to review and summarize the evidence of stroke rehabilitation research. The purposes of this program, as outlined by the panel, are maintaining timely and accurate information on effective stroke rehabilitation, identifying areas for further research, supporting continuous peer review, and encouraging improved evidence-based practice.

In 2001, the Ministry provided funding to the Foundation in support of this recommendation. The Foundation was pleased to identify and encourage this Consensus Panel on Hemiplegic Arm and Hand as a significant contribution to this work.

This initiative is part of a comprehensive stroke strategy outlined in *Towards and Integrated Stroke Strategy for Ontario*, the Report of the Joint Ministry of Health and Long-Term Care and Heart and Stroke Foundation of Ontario Stroke Strategy Working Group. The Ministry announced its commitment to implementation in June 2000 and now there are six Regional Stroke Centres designated to provide leadership in the development of regional stroke strategies across the full continuum of care.

Susan Barreca is to be thanked and congratulated for her leadership in convening this consensus panel. The Heart and Stroke Foundation of Ontario looks forward to working with the Regional Stroke Centres to ensure that the knowledge gained is transferred into practice.

ACKNOWLEDGEMENTS

Funding was provided to Susan Barreca by the Ministry of Health and Long Term Care, as part of the Ontario Integrated Stroke Strategy 2000, and is gratefully acknowledged. It should be noted that the opinions expressed are those of the consensus panel and no official endorsement by the Ministry is intended or should be inferred.

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Thank you all.

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WHAT SHOULD I BE DOING?

Summary of the Recommendations of the 2001 Consensus Panel on the Management of the Hemiplegic Arm and Hand

Stroke survivors want to regain functional use of their affected arm and hand. Clinicians in the field of rehabilitation science want very much to make this happen. This interest in the post-stroke upper limb is evidenced by a three-fold increase in published studies during the past 10 years. However, as an OT, PT, or physician, we struggle within a client-centered model of health care to balance our clients' desire to receive intensive therapy for his or her hemiplegic arm and hand with the restraints of limited time and resources. Which stroke survivor with arm and hand dysfunction has the potential to regain functional use of his or her arm and hand? What should I be doing to provide " best practice"?

The 2001 Consensus Panel clearly addresses these key issues in the management of the post-stroke arm and hand. This report was developed in a rigorous fashion by a team of expert researchers and clinicians from Canada and the United States. Two librarians searched the scientific literature electronically in order to provide a reproducible methodology. Additional articles were produced by manual searches of the rehabilitation literature and suggestions from the panel members. From a total of 333 articles, three referees selected 112 relevant references. Critical appraisal of the methodological quality of these studies was conducted using a measure with known reliability and evidence of validity f or randomized and nonrandomized clinical trials. Data were extracted and synthesized into clinically appropriate categories. When results of the clinical trials (randomized control trials and cohort studies) were similar enough to be combined, a series of meta-analyses were done under the supervision of Dr. Andy Willan, Professor of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario. Prior to the consensus meeting in June, panel members were actively involved in reviewing the summary report of the scientific evidence.

As well, the panel members approved nine clinical scenarios that highlighted common or clinically important issues in the management of the hemiplegic arm and hand. Scenarios were selected that emphasized specific cues that may determine the way we, as clinicians, would manage one stroke survivor with upper limb dysfunction versus another. These cues, identified from the review of the literature and from the panel members, represented varying degrees of impairment and functional deficits that are commonly present in our clients following a stroke. Upper limb motor recovery was classified into separate stages using the Chedoke-McMaster Stroke Assessment that established a common language amongst the panel members and avoided any ambiguity arising from descriptive phasing.

The panel met in Hamilton, Ontario for a day and a half to form treatment recommendations. In addition to the summary report of the scientific evidence, the cohort studies were further synthesized into tables and charts that facilitated the application of the literature to each scenario. Two main principles guided the formulation of the treatment recommendations: (1) the results of studies that not only had a control and a treatment group but whose subjects also matched the time post-stroke in each scenario; and (2) expert opinion that could be supported by scientific evidence extrapolated from the general literature. The facilitator enhanced the consensus process by guiding the discussions and recording the initial recommendations. Final rewording of these recommendations occurred during a teleconference.

Voting for each recommendation was implicit (agree or disagree) with the voting occurring by email. There was **strong consensus (8 out of 9 members)** on every treatment recommendation. The report was sent to seven external reviewers for additional feedback. Their comments were reviewed and incorporated into the final consensus report.

The treatment recommendations deal with clinical problems that are often seen in the management of the hemiplegic upper limb. These include: (1) the need to prevent and/or treat shoulder pain; (2) identifying best practice methods for a client with a hemiplegic arm and hand that is *unlikely* to regain functional ability; and (3) identifying best practice methods for a client with a hemiplegic arm and hand that is *likely* to regain upper limb function. Because the Chedoke predictive equations indicate that recovery of the hemiplegic arm and hand is highly predictable, the panel endorses their use in treatment planning. The issue of shoulder pain needs to be addressed. Treatment should focus on the prevention of shoulder pain and when that is not possible, therapists must use evidence-based methods to manage the pain effectively. When the predictive equations indicate an anticipated outcome of low motor recovery (less than Stage 4), the panel strongly feels that treatment should focus on achieving and maintaining a comfortable, mobile arm and hand. For those clients who are predicted to achieve a higher degree of motor recovery in their arm and hand (Stage 4 or higher), every opportunity should be given to these clients to regain function in their affected upper limb.

This evidence-based document, which builds upon the 1994-95 AHCPR clinical guidelines, offers more specific recommendations for the post-stroke arm and hand. The opinions of the consensus panel were not governed by either prevailing treatment approaches or by the total number of treatments permitted within each respective country.

The panel thanks the Heart and Stroke Foundation of Ontario and the Ontario Ministry of Health and Long Term Care for their generous support. The Consensus Panel hopes that these recommendations will encourage clinicians to re-evaluate their practice and initiate research activities to address crucial gaps in our knowledge about treating the post-stroke arm and hand.

Bottom Line

Prevent shoulder pain and if unable to do so, manage should pain effectively.

Be selective when choosing compensatory versus remedial intervention methods to treat clients who are predicted to have a low return of motor function and poor functional use of their arm and hand.

Provide remedially -focused rehabilitation to clients who are predicted to change in arm and hand function.

Use measures of known reliability and evidence of validity for treatment planning and outcome prediction.

Do research to build upon the evidence that has been evaluated in these guidelines.

CONSENSUS EXERCISE: CLINICAL PRACTICE GUIDELINE FOR THE HEMIPLEGIC ARM AND HAND:

I Foreword

This clinical practice guideline on the hemiplegic arm and hand aims to: (i) set treatment standards that will be incorporated into clinical pathways; (ii) help stroke survivors, clinicians, and health care payers obtain the optimal cost-effective outcomes; (iii) identify research priorities; and (iv) act as a catalyst to bring research into the clinical setting. This guideline addresses the complex issues surrounding management of the post-stroke arm and hand, expanding the body of work, Post-stroke Rehabilitation Clinical Practice Guideline, published by the Agency for Health Care Policy and Research (1995). In light of diminishing health care resources, clinicians need to discriminate between (a) stroke survivors who need intensive treatment to rehabilitate their hemiplegic upper limb and (b) those clients who would be better served by being taught compensatory techniques and how to maintain a comfortable, mobile arm and hand. The purpose of this guideline, based on the effectiveness literature and expert opinion, is to clarify outcomes and expectations for the stroke survivor, reduce variations in clinical practice, and lessen uncertainty in the management of the post-stroke arm and hand (Browman et al., 1995, 1998).

II Rationale

Prevalence

Stroke is one of the main causes of death and disability among older adults. Although most stroke survivors regain independent ambulation, many have difficulty performing activities of daily living, especially their self-care and household duties (Dombovy, 1993). Rehabilitation of the hemiplegic upper limb remains difficult to achieve, with only 5% of stroke survivors who have complete paralysis regaining functional use of their impaired arm and hand (Dombovy, 1993; Duncan, 1999; Gowland, 1982; Kwakkel, 2000). Limited rehabilitation resources, time constraints, and a lack of early motor recovery in the arm and hand tend to focus therapy on improving balance, gait, and general mobility. This practice pattern is very common, with few facilities providing intensive therapy for the arm and hand.

Burden of illness

Stroke survivors place a high value on the return of upper limb function. McEwen-Hill & Gowland (1989) found that 75% of the clients they interviewed were physically unable to participate in the same type and amount of hobbies or activities they had previously. As well, 50% of this group specifically mentioned problems with arm function (McEwen-Hill & Gowland, 1989). Similarly, Drummond (1990) found that impaired hand function prevented half of 109 stroke survivors interviewed about their leisure activities from taking part in desired recreational activities. When those disabilities attributed to co-morbid conditions were removed from a list of functional deficits, Gresham and Granger (1987) reported that stroke survivors not only showed a significant increased dependency in activities of daily living but also a significant decrease in interests and hobbies as compared to their matched controls.

Consequently, clinicians face a dilemma within today's client-driven model of health care. On the one hand, therapists wish to respect clients' goals for more therapy on their affected arm and hand. On the other hand, clinicians do not want to use valuable treatment time or raise false expectations if little recovery of the upper limb is expected. In fact, one group of researchers (Sunderland, Fletcher, Bradley et al., 1994) questioned the effectiveness of providing upper limb

retraining rather than teaching one-handed compensatory mechanisms. Therefore, it becomes important to be able to predict which stroke survivors will change and benefit from intensive upper limb therapy.

Potential for significant benefits or risks
Many different therapeutic techniques are currently used to treat the hemiplegic upper limb, often without a scientific basis due to the paucity of research studies that have concluded a positive effect. Development of treatment recommendations, based on the effectiveness literature to date and expert opinion, is beneficial in establishing the most efficient management of the hemiplegic upper limb. This guideline of "best practice" will assist clinicians and payers in choosing appropriate combinations of treatment techniques for specific clients. More importantly, stroke survivors want access to reliable and valid information so they are empowered to discuss management of their post-stroke arm and hand and make informed decisions about the course of treatment.

There is a need for a common language that classifies motor impairment of the upper limb into separate sub-groupings with distinct problems, predictive outcomes, and common goals. The guideline may act as a catalyst to categorize stroke survivors with upper limb dysfunction into homogenous groups so that sample sizes may gain enough power to detect small effect sizes. This guideline will help foster logical prediction, treatment, and evaluation decisions.

Greater understanding around the management of the painful upper limb post-stroke is a key area for clinicians and clients alike. The incidence of shoulder pain in the hemiplegic shoulder is high, ranging from 5% to 84% (Vanspall, Richardson, Moreland, 1999). A clinical practice guideline would help identify factors that contribute to hemiplegic shoulder pain and provide a consensus as to how best to treat these upper limbs. Practice consistency around the treatment of the painful hemiplegic shoulder and/or hand would increase service delivery throughout the continuum of care, from the acute setting to the client's home.

Relevance to local practice patterns
Within the last few years, there is more interest in the motor recovery of the hemiplegic arm and hand, as evidenced by a threefold increase in reported studies in the last 11 years. A recent symposium on the hemiplegic upper limb (First Annual Stroke Rehab Symposium, Mitchner Institute, Toronto, 2000) had a capacity audience of 332 clinicians with a waiting list of 132 applicants. Given these trends, the development of a clinical practice guideline for the hemiplegic upper limb comes at an opportune time to influence the direction of research and best practice within the clinical setting.

Degree of variation in health care practice
Diverse practices exist in the management of the post-stroke arm and hand, with either agreement or disparity between the evidence and clinical practice. For example, there is strong support from the literature (Level l1 evidence) that the use of pulleys should be avoided in the treatment of the hemiplegic arm and hand (Kumar et al., 1990); this evidence is widely incorporated within the clinical setting. On the other hand, there is a high degree of evidence (Level 1) confirming that neurodevelopmental treatment (NDT) is no more or less effective than several other therapeutic approaches in the treatment of the hemiplegic arm and hand (Basmajian et al., 1987; Dickstein et al., 1986; Gelber et al., 1995; Logigan et al., 1983; Lord et al., 1986; Vanderlee et al., 1999). Still this technique is widely promoted through a series of certification courses taught in PT/OT curricula. In contrast, the literature supports the use of biofeedback-

neuromusucular electrical stimulation (EMG-NMS) in the treatment of the hemiplegic wrist and forearm (Level 1 evidence), which has not yet gained broad clinical application (Bowman & Baker, 1979; Cauraugh et al., 2000; Francisco et al., 1998; Heckman, 1997; Kraft et al., 1992).

Likelihood to change practice
North American Schools of Physical Therapy and Occupational Therapy emphasize the importance of evidence-based practice. Reviews, meta-analyses, and clinical practice guidelines have become easily accessible through local and national peer organizations. The vision of the Heart and Stroke Foundation of Ontario, "that stroke survivors have timely access to the appropriate intensity and duration of rehabilitation services," acts as an additional impetus to use clinical practice guidelines (Stroke Rehabilitation Consensus Panel Report, May 2000).

Costs
As stroke survivors spend less time in the acute care setting, clinicians are challenged to assess thoroughly, meaningfully, and quickly in order to provide best practice and appropriate discharge planning. Third party payers and managed care organizations demand relevant treatments that do not duplicate services. Until recently, poor functional outcomes for the upper limb resulted in little being done to change the poor prognosis. However, recent studies show that changes that may occur in the chronic post-stroke upper limb encourage clients to demand more treatment. A clinical practice guideline would help determine which stroke survivor would benefit from continued intensive treatment. In this way, available resources would be best utilized.

Availability of high quality evidence to support practices
To date, 33 randomized control trials examined the efficacy of various treatments for the hemiplegic upper limb. The quality of these RCT, as critically appraised with Down's and Black's Checklist for Methodological Assessment Quality (range, 1-27), varied from 9-27, with a mean score of 18.8 (SD 4.3), 95% CI (10.4, 27.2). Half of the 6 systematic reviews had above average quality while 3 reviews had below average quality, as measured by the Oxman-Guyatt Index for Assessing the Quality of Systematic Reviews (Jadad, 1996). There were 29 cohort studies (contemporaneous or historical with a control group) that had a mean quality rating of 12/27 on the Down and Black's (1998) checklist.

III Goals of the Guideline

The main goal of this guideline is to improve the delivery of care so that a stroke survivor with upper limb dysfunction may achieve the best possible functional outcome and quality of life. Specific goals are:

- encourage clinicians to re-examine their practice
- summarize for health care professionals cost effective therapy to achieve the best possible outcome
- disseminate the guidelines to clinicians and researchers
- improve the public understanding of the complex issues that surround recovery of the hemiplegic arm and hand
- initiate future research to address crucial gaps in our knowledge about treating the post-stroke arm and hand

IV. Methodology (Eady et al., 1997)

Funding

The Heart and Stroke Foundation of Ontario and the Ontario Ministry of Health and Long Term Care provided funds to Susan Barreca for the development of a clinical practice guideline for the post-stroke arm and hand.

Panel selection

The panel was composed of members who demonstrated clinical expertise and interest specific to the hemiplegic upper limb. Prospective names for the consensus exercise were gathered from the literature and from other clinicians known to do research in this area. Representation on the panel came from the disciplines of physical medicine, occupational therapy, and physical therapy. Short biographical descriptors of the panel members are contained within this report.

Susan Barreca	Dr. Susan Fasoli	Dr. Vlasta Hajek
Dr. Richard Bohannon	Carolyn Gowland	Maria Huijbregts
Ann Charness	Jeremy Griffiths	Dr. Steven Wolf

Panel moderator

The panel moderator was Mary Ann O'Brien, a researcher/ physiotherapist/university lecturer with considerable experience in literature review, meta-analysis, and policy formulation.

Question(s)

Nine questions were designed that reflected common clinical problems in the management of the post-stroke arm and hand. The purpose of these questions was to focus the consensus process on the evidence and to assist decision-making while generating the treatment recommendations. Four of the questions dealt with the management of shoulder pain while the other five focused on management of the hemiplegic arm and hand in varying stages of motor recovery. The questions pertained to scenarios containing relevant cues that described the target population, important indicators of the problem and outcome(s) of interest. This format of scenario/question was similar to that developed by the Ontario Cancer Treatment Practice Guidelines Initiative (1997). In this way, the treatment recommendations focus on ways to manage a specific problem rather than on ways of using a specific intervention. The advantages to this method are twofold: (1) it reflects the clinician's role in deciding how best to treat the hemiplegic arm and hand; and (2) it ensures that panel members consider alternatives when judging the appropriate use of any single intervention.

Search for evidence

Two individual searches of the scientific literature including MEDLINE, CINOHL, EMBASE were carried out for the years 1966 to June 2001 using the subject headings stroke, cerebrovascular disorders, hemiplegia, hemiparesis, adult, arm and hand, upper limb, upper extremity, rehabilitation, clinical trials, intervention (see Appendix). Electronic searching was first conducted in order to provide a methodology for reproducing similar results. Out of a total of 333 articles, 112 were defined relevant (Appendix G). Between the two library searches, 69 articles were identified. The remaining 43 references came from secondary searches (i.e. manual search of the rehabilitation literature, bibliographies of the primary references, and recommendations from experts). Animal studies, psychology literature that lacked clinical relevance, abstracts, government literature, books, and manuscripts other than those written in English were excluded. Authors were not contacted for additional data.

Article selection

Articles of interest were practice guidelines, systematic reviews, randomized controlled trials, cohort studies, case series with greater than 10 subjects, and single subject design with a protocol that described an intervention for the adult hemiplegic arm and hand. Articles were selected based on the title and the abstract. The principal investigator and one of two raters (staff physiotherapists) reviewed the two library searches, marking the articles as relevant, not relevant, unlikely but possible (retrieve) or unable to tell from reference (retrieve). Where there was disagreement between the raters, consensus was reached through discussion. Articles were excluded for the following reasons: (i) not an intervention study, (ii) target population contained other diagnoses than stroke (e.g. head injury), (iii) case series with less than 10 subjects, (iv) descriptive case studies with no set protocol; (v) no separate analyses, with data, for the upper limb, (vi) descriptive reviews, and (vii) on subjects with normal musculature

Assessment of methodological quality

Two research OT interns, in their final year at McMaster University, were trained to use a standardized checklist, (Downs and Black, 1998). Along with their supervisor, they assessed the 62 randomized controlled trials and cohort trials. Using Spearman Correlation, the inter-rater reliability (n=3) for the Downs and Black's Checklist (Appendix E) was statistically significant, $r=0.90$, 2-tailed, $p=0.002$ on 8 observations chosen at random. Twenty-five therapists (physiotherapists and occupational therapists from HHSC and St. Joseph's Hospital's, Hamilton) received a half-hour workshop on critical appraisal and then reviewed, on average, 5 articles each using a generic "clinician friendly" checklist (Appendix E). The checklist helped in the data extraction from the relevant articles. Three raters evaluated the cohort and randomized controlled studies; two raters evaluated all 112 articles. Spearman Correlation between the Downs and Black's Checklist and the "clinician friendly" checklist was statistically significant, $r=0.65, p<0.001$ on 62 observations. The principal investigator assessed the systematic reviews using the Oxman-Guyatt Instrument for Assessing the Quality of an Overview (Jadad, 1996, Appendix E).

Data Extraction

Data of the characteristics and findings from each relevant article were extracted under the following headings: author, year, design, methods (random assignment, concealment of random assignment, blinding to treatment assignment), participants, average time post-stroke, interventions, outcomes, notes, and critical appraisal rating and placed in a table (Summary of the Effectiveness Literature). Additional tables and charts that further synthesized the effectiveness literature were constructed for quick reference for the panel to use during the consensus exercise; they categorized studies relevant to each scenario, listing the type of invention, study design (RCT or cohort), time post-stroke, critical appraisal score, and whether the results were statistically significant.

Synthesizing the Evidence

Studies were combined into clinically relevant categories (see table of contents). Where clinical trials (RCT and cohort studies) were judged similar enough in population, time post-stroke, intervention, and outcome to combine the data, a quantitative synthesis of the evidence was done under the supervision of Dr. Andrew Willan, statistician and clinical trial methodologist at McMaster University, Hamilton, Ontario. As the p- value, effect size or binary data was not always available to allow clinically relevant studies to be combined, the Z statistic was used as the common denominator (Becker, 1994).

Consensus exercise

The format of this consensus exercise attempted to address potential biases in decision -making that have been identified by Murphy et al. (1998). Prior to the consensus exercise, the panel members communicated by email with each other; as a group, they discussed their own treatment philosophies, approved the format of the clinical questions, and reviewed the results of the literature searches. The nine panel members represented a mix of clinicians and researcher/academics from occupational therapy, physiotherapy, and physical medicine. The panel was large enough to produce a variety of opinions but not so large as to be unmanageable as a group. Members were seated alphabetically at a U-shaped table in a hotel conference room. Skilful facilitation by the moderator helped to mitigate the effects of status. Information was presented in a synthesized way that was easy to read and which emphasized the elements on which judgments should be based (type of study, quality of the methodology). In this way, the summary report of the scientific evidence encouraged the panel members to base their opinions on the relevant research. During the consensus exercise, treatment recommendations were drafted for each scenario and projected unto a screen. Panel members had two more opportunities to reword the final draft of the treatment recommendations. Voting was implicit (agree or disagree) and conducted by email, with each member voting independently.

The scope of the guideline focused specifically on the management of the hemiplegic arm and hand from acute care, rehabilitation, outpatient therapy to home. The clinical recommendations of the guideline were carefully formulated by first addressing treatment interventions based on the existing evidence outlined in the summary of the scientific evidence at the back of this report. *Only those studies that had a control group (cohort or randomized control trial) were used for evidence;* furthermore, the panel was careful to ensure that the time post-stroke in the studies matched the cues in the scenarios. The strength of those studies that formed the basis for specific treatment recommendations were ranked (I-V) using Sackett's (1996) levels of scientific evidence. Where there was no supporting evidence in the literature, expert opinion was offered. However, *expert opinion was only considered where the panel felt confident that the offered opinion could be supported in part by scientific literature.* There were instances where panel members were aware of different modalities and techniques that are often used in the clinical setting; however, if panel members were not cognizant of any research in either the orthopedic or neurology literature that could be applied with confidence to a specific scenario, the treatment intervention was not included.

External expert review panel

Selected expert clinicians and academics were asked to review the final document. An appraisal instrument with known reliability was used to assess the quality of the clinical guideline (Cluzeau et al., 1999). Feedback from the external reviewers was incorporated into the final report.

Appraisal instrument dimension	Yes	No	Not Sure	Not Applicable
Rigour of the development process (out of a total score of 20)	mean, 11 SD=2.6	mean, 3 SD=0.9	mean, 5 SD=1.9	mean, 1 SD=0
Context and content (out of a total score of 12)	mean, 6 SD=1.3	mean, 3 SD=1.8	mean, 2 SD=0.9	mean, 1 SD=0

Intended audience

This guideline is intended to target healthcare professionals who treat clients post-stroke. It is specifically directed at the patient who has a first stroke with some degree of hemiparesis. Most recommendations may also apply to a stroke survivor with a recurrent stroke or with stroke related neurological impairments in the absence of hemiparesis but there is no evidence to date.

Methodological attributes and limitations

This clinical practice guideline, based on the best available research and expert opinion, has been systematically developed according to a well-documented protocol. A review of the research that was synthesized under the supervision of a methodologist was provided to the panel members at an early stage. Every effort was made to avoid biases in the search strategy and in the selection of relevant articles. The quality of the studies was graded using a reliable method. The interactions of the panel members were structured and facilitated by an experienced moderator in order to mitigate any biases of the panel members. This document underwent external review, incorporating many of their suggestions. Every effort has been made to present the treatment recommendations and the summary of the scientific evidence in a clear, easy-to read manner. We recognize some of the limitations of this clinical practice guideline. We did not review certain areas of the literature that may be used in informed decision making, such as the body of literature that addresses the neural and behavioural mechanisms of motor recovery in the hemiplegic upper limb. The composition of the panel lacked a consumer (stroke survivor) representative. The majority of the panel had a physiotherapy background. Although some panel members currently hold academic positions, all had a strong clinical background. During the consensus exercise, formal methods tried to offset any potential biases in decision-making by: (1) having a large panel of 9 members; (2) insisting on reasoned arguments where assumptions were challenged and members were forced to justify their views; (3) incorporating scientific methodology; and (4) having members vote independently where 8 out of 9 votes was required to have strong consensus.

Future direction

The Heart and Stroke Foundation of Ontario has agreed in principle to support Susan Barreca and the panel in the task of reviewing and updating this clinical practice guideline. The target date for this review is set for December 2006.

Conclusions

The recommendations for the management of the hemiplegic arm and hand have been based on the critical appraisal of the effectiveness literature to date and expert opinion. The panel hopes that this guideline will act as a catalyst for therapists to review their clinical practice. There is no doubt that more research is greatly needed. There is a gap between relevant clinical problems and the evidence that exists to date. There are many modalities and techniques that are in current use in the clinical setting (e.g. ice, ultra-sound, hot packs, weights, springs, hand splints, compressive units) that need to be examined. The panel hopes that this guideline will encourage further research to address these gaps between our knowledge and our practice.

Glossary

- **Stroke**

A modified version of the World Health Organization (1989)'s definition of stroke in adults, 16 years and older, was selected (Stroke Rehabilitation Consensus Panel Report, 2000). Stroke is "an acute neurologic dysfunction of vascular origin with sudden or at least rapid occurrence of symptoms and signs corresponding to the involvement of focal areas in the brain. Focal brain injury arising from vascular neck trauma is included but acquired traumatic injury to the brain in excluded. Also excluded from this definition are syncopes of cardiac and other origin, diffuse brain injury due to inflammation, infection, subarchnoid hemorrhage, anoxia, and cardiac arrest."

- **Arm** (Moore and Dalley, 1999)

Consists of three segments: (1) the pectoral girdle consisting of the bony ring, incomplete posteriorly formed by the scapulae and clavicles, which is completed anteriorly by the manubrium of the sternum; (2) the arm consisting of the part between the shoulder and elbow containing the humerus which connects the shoulder and the elbow; and (3) the forearm consisting of the part between the elbow and wrist containing the ulna and radius which connect the elbow and wrist.

- **Hand** (Moore and Dalley, 1999)

Consists of the part of the upper limb distal to the forearm containing the carpus, metacarpus, and phalanges that is composed of the wrist, palm, dorsum of hand, and fingers including the thumb.

- **Spasticity** (Johnson, 2001)

Spasticity, which is directly equated with spastic hypertonia, is a motor disorder that is 'characterized by a velocity-dependent increase in the tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from the hyper-excitability of the stretch reflex, as one component of the upper motor neuron syndrome following a lesion at any level of the corticofugal pathways - cortex, internal capsule, brainstem or spinal cord'.

- **Stages of motor recovery of the Chedoke-McMaster Stroke Assessment** (Gowland et al., 1993)

Stage 1
Flaccid paralysis is present. Phasic Stretch reflexes are absent or hypoactive. Active movement cannot be elicited reflexively with a facilitory stimulus or volitionally.

Stage 2
Spasticity is present and is felt as a resistance to passive movement. No voluntary movement is present but a facilitory stimulus will elicit the limb synergies reflexively. These limb synergies consist of stereotypical flexor and extensor movements.

Stage 3
Spasticity is marked. The synergistic movements can be elicited voluntarily, but are obligatory.

Stage 4
Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movement combining antagonistic synergies can be performed when the prime movers are the strong components of the synergy.

Stage 5
Spasticity wanes, but is evident with rapid movement and at the extremes of range. Synergy patterns can be reversed even if the movement takes place in the strongest synergy first. Movements that utilize the weak components of both synergies acting as prime movers can be performed.

Stage 6
Coordination and patterns of movement can be near normal. Spasticity as demonstrated as resistance to passive movement is no longer present. Abnormal patterns of movement with faulty timing emerge when rapid or complex actions are requested.

Stage 7
Normal. A "normal" variety of rapid, age appropriate complex movements patterns are possible with normal timing, coordination, strength and endurance. There is no evidence of functional impairment compared to the normal side. There is a " normal" sensory- perceptual motor system.

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V. Levels of Scientific Evidence About Therapeutic Interventions

Level I evidence
Randomized controlled trials (RCT) that are big enough to be either
(1) positive, with small risks of false-negative conclusions, or
(2) negative, with small risks of false-negative conclusions, or
(3) meta-analyses

Level II evidence
Randomized controlled trials that are too small, so that they show either
(1) positive trends that are not statistically significant, with a larger risk of false-positive conclusions or
(2) no impressive trends, but large risks of false-negative conclusions (low power)

Level III evidence
Formal comparisons with nonrandomized contemporaneous controls

Level IV evidence
Formal comparison with historic controls

Level V evidence
Case series

Expert Opinion

Strong Consensus	Agreement among 90% or more of panel members and expert reviewers
Consensus	Agreement among 75-89% of panel members and expert reviewers

Sackett DL. (1996). Levels of evidence and clinical decision making. In Clinical decision making in rehabilitation ; Efficacy and outcomes. JV Basmajian and SN Banerjee (Editors), Churchill Livingstone, New York

Panel Members for the 2001 Consensus Exercise

Susan R. Barreca (PT, B.A. (Psych)

Affiliations

- Research clinician (Part-time), Adult Specialized Rehabilitation Services, Hamilton Health Sciences
- Physiotherapist (Part-time), Stroke Team, Chedoke campus, HHSC
- Clinical Lecturer, School of Rehabilitation Sciences, McMaster University

Research Interests/Activities

- Principal Investigator, Development of the Chedoke Arm and Hand Activity Inventory
- Chairman, Consensus Panel for the Development of Guidelines for the Management of the Hemiplegic Arm and Hand
- Chedoke Stroke Assessment Research Team member
- Principal Investigator, examining cognitive factors that impact on the motor recovery of the post-stroke arm and hand

My research focuses on two main objectives: (i) to improve the delivery of care to stroke survivors, and (ii) to improve the quality of life in those clients with neurological deficits. I am currently completing a two year study which attempts to elicit reliable yes/no responses in those clients with severe acquired brain injuries who score Level IV or less on the Ranchos Los Amigos Cognitive Functioning Scale as well as determining how many times a stroke survivor needs to practice the act of coming up into standing from sitting in order to do it safely and consistently.

For a long time, I have been interested in the motor recovery of the hemiplegic upper limb. This year I was awarded funds through the Ministry of Health and Long Term Care to (i) synthesize the effectiveness literature on the hemiplegic arm and hand and (ii) to bring together experts in the field to develop treatment recommendations around the management of the post-stroke upper limb. It is with great pleasure and honor that this consensus exercise is taking place.

Dr. Richard W Bohannon, EdD, PT, NCS

Dr Bohannon received his Bachelor's and Master's degrees in physical therapy from the University of North Carolina at Chapel Hill. His doctorate in Adult Education was awarded by North Carolina State University in 1988. Dr Bohannon has 24 years of active clinical experience in acute care, rehabilitation, and home care settings. Although involved with a broad spectrum of adult patients, Dr Bohannon's chief clinical focus is on patients with neuromuscular impairments and disability. Patients with impairments in strength and balance are of particular interest. Dr Bohannon is a board certified specialist in Neurologic Physical Therapy and a Fellow of the Stroke Council of the American Heart Association. He has served as a consultant to the Agency for Health Care Policy and Research, the Malaysian government, and several health care products companies. He served on the American Physical Therapy Association's Neuromuscular Panel of Experts which assisted in developing "A Guide to Physical Therapist Practice, Part Two: Preferred Practice Patterns." He has provided expert opinion for legal cases and case review. Dr Bohannon is presently a Professor at the University of Connecticut, a Senior Scientist with the Institute of Outcomes Research at Hartford Hospital, and a therapist with Eastern Rehabilitation Network. Dr Bohannon is a prolific writer with over 300 publications in over 20 different journals to his credit. Dr Bohannon serves various roles on numerous editorial boards and on the boards of the American Society of Neurorehabilitation and CINAHL Information Systems. He has lectured internationally on an array of topics. Dr Bohannon has a passion for fostering evidence-based practice.

Ann L. Charness, PT, MS

Ann L. Charness, PT, MS is an Assistant Professor in the Programs in Rehabilitation Sciences at MCP Hahnemann University in Philadelphia Pennsylvania. where she teaches in the entry-level DPT and post-professional movement science programs. Ann is currently enrolled in a doctoral program in advanced neurological studies at Rocky Mountain University, and her research focus in the program is in the area of falls in the frail elderly as well as those with stroke or Parkinson's Disease. Over the past few years Ann has been collaborating with Dr. Nathaniel Mayer at Moss Rehab Hospital in Philadelphia on a computerized upper extremity rehab work station for patients with stroke or traumatic brain injury, that would allow the practice repetitions needed to relearn reach grasp and manipulation. Ann serves on the editorial board of the journal, Topics in Stroke Rehabilitation, and is a reviewer for Lippincott, Williams, Wilkins, and Butterworth Heinemann publications. Ann is the immediate past-president of the Aquatics Section of APTA. She was a contributor to the Compendium on Teaching Neurologic Content published by the Neurology Section of APTA. Ann is excited to participate in this panel first for the opportunity to collaborate with colleagues who are experts in upper extremity rehabilitation in Canada and in the United States, second to review the most current literature in the area of upper extremity recovery, and most of all to move our profession a step closer to evidence-based practice in the area of treatment of the upper extremity in stroke.

Dr. Susan Fasoli, ScD., OTR/L

I am currently a post-doctoral fellow in the Department of Mechanical Engineering at the Massachusetts Institute of Technology (MIT). As a result of this position, I hold a research appointment at Spaulding Rehabilitation Hospital in Boston, Massachusetts, and have ties with Burke Rehabilitation Hospital in White Plains, New York. We are examining the effects of repetitive, robot-assisted therapy on upper extremity motor performance in persons with either acute or chronic stroke. To date, we have primarily focused on robotic therapy for shoulder and elbow movements of the involved limb, but are in the process of developing other shoulder, wrist, and hand devices that we expect to test in the near future. My main interests in this research are to a) to examine how this intervention influences motor organization and recovery after stroke, b) identify ways to better integrate robot-assisted therapy into rehabilitation programs, and c) enhance the functional relevance and carry-over of robot-assisted movements during daily tasks. We are beginning to use performance indices (e.g. motor accuracy, velocity etc.) that are derived from robot data to more quantitatively and objectively measure changes in motor performance.

My clinical and research interests have focused on occupational therapy intervention with adults who have neurological diagnoses, particularly CVA. My doctoral research at Boston University focused on the effects of instruction (context) on movement kinematics of the affected limb in persons with stroke. I agreed to participate in this consensus exercise for several reasons. I have a long-term interest in better understanding the mechanisms that contribute to improve upper extremity recovery and function after stroke. I think that I cannot only contribute what I have learned over the years to this consensus exercise, but am looking forward to learning others' perspectives on upper extremity rehabilitation. I think this process will help to solidify my own thinking. I strongly believe that we need more effective evidence-based therapy for motor impairments after stroke, and think the consensus exercise will take us one step forward in achieving that goal.

Carolyn (Kelley) Gowland

I joined the staff of Chedoke Rehabilitation Centre in 1970 as a Senior Physiotherapist in Stroke. Over the years I held the positions of Clinical Instructor, Clinical Specialist in Neurology, and Director of Research. When I moved to the University full time in 1989, I continued with my hospital affiliation as Research Manager in Pediatrics, neurology and long-term care, and in 1991 with an Associate Appointment in Research. I continued in this position until my retirement in 1996. Since my retirement, I have continued to function as a member of the Chedoke-McMaster Stroke Research team as a research mentor.

I joined the faculty of McMaster University in 1982 on a part-time basis before moving to the university full time. I progressed through the ranks to finish as a tenured Associate Professor. Throughout my years at the University, I worked with many graduate students whose research focused in the area of stroke.

My research focused on clinical research, mostly in the area of measurement. The two principal measures I was involved in the development and validation of were the Chedoke McMaster Stroke Assessment and the Gross Motor Function Measure (a measure of physical functional development for children with cerebral palsy or Down's Syndrome). I was an investigator in the Neurodevelopmental Clinical Research Unit from its conception in 1989 until my retirement.

I feel extremely pleased and honored to be part of this panel. I have a great deal of interest in the clinical application of research findings and have come to understand that most clinicians, while very busy in their day to day life, want to participate in evidence-based practice. They welcome information in a usable format such as in Clinical Practice Guidelines. The use of a Consensus Exercise to develop these guidelines is an excellent adjunct to practice.

Jeremy Griffiths (B.Sc.PT, H.N.C. Civil & Structural Engineering

- Physiotherapist, Hamilton Health Sciences Corporation, specialized in stroke rehabilitation
- Trained in cognitive behavioral management of chronic pain with experience in workplace assessment and adaptation
- Expert in Fitness management and workplace assessments
- Participates in clinical teaching at McMaster University and acts as a student preceptor

RESEARCH

- Clinical investigator, development of the Chedoke Arm and Hand Activity Inventory
- Principal investigator, Efficacy of the Walk-Aide, a peroneal nerve stimulator for the post-stroke dropped foot.

I believe that our current knowledge around treatment practices of the hemiplegic arm and hand is lacking and would like to play a role in changing that. Being on the panel stimulates me to be better acquainted with the literature, to open myself to change my practice, and to look more critically at the effectiveness of my treatment. I would like to be more involved in research and this is a step in that direction.

Dr. Vlasta Eva Hajek

Clinical Affiliation

Physiatrist with appointments as a consultant or active staff in Physical Medicine and Rehabilitation at several leading Toronto hospitals including:

- Toronto Rehabilitation Institute. Providing in-patient care on Stroke Program and through consultations on geriatric, psychogeriatric, and complex continuing care programs. Providing outpatient care through Outpatient Rehabilitation Assessment Clinic (OPRA).
- University Health Network (Toronto General, Western, and Princess Margaret Hospitals).
- Active staff member providing in-patient and outpatient consultations and care at the Centre for Addiction and Mental Health.
- North York General Hospital, Branson and General Divisions, consulting staff providing in-patient and outpatient consultations and care.

Academic Rank

- Assistant Professor, July 1985 to present, Department of Rehabilitation Medicine, University of Toronto. Activities include:
- Teaching of undergraduate medical students. Electives for students from University of Toronto and other universities, years I to IV.
- Teaching of postgraduate medical students. Physiatry and geriatric electives for residents, and elective sabbaticals for post-doctoral fellows.

Medical research

- Principal Investigator for a clinical research project: *Treatment of Shoulder-Hand Syndrome Using Sensory Stimulation*. A 2- year grant of $49,600 received from The Research Institute of the Toronto Rehabilitation Institute, 1998.
- Active involvement in many successfully completed and implemented clinical research projects supported by research grants awarded by the Research Institute of the Toronto Rehabilitation Institute, Gerontology Research Council of Ontario, and by other organisations and sponsors.

Reasons for participation

I agree with the need to increase the interaction between those involved in the treatment of hemiplegic upper limb, to develop new treatment techniques, to share experiences, and to stimulate research

Maria P.J. Huijbregts (PhD. Candidate, MHsc., B.Sc PT

Appointments and Affiliations

- Coordinator, Evaluation & Outcome, PT Department. Baycrest Centre for Geriatric Care.
- Lecture**r** (Academic Status Appointment), Department of Physical Therapy, University of Toronto

Pertinent Research Interests and other Activities

- Participation in the development of the Chedoke Arm and Hand Activity Inventory.
- Development and validation of the Continuing Care Activity measure.

Expertise in Stroke Rehabilitation

- Member of Toronto District Health Council Coordinated Stroke Strategy Panel, 2000
- Member of expert panel on Rehabilitation Report 2001 Feasibility Study
- Development and evaluation of a community stroke self management program
- Member of Stroke Recovery Committee of the Heart and Stroke Foundation of Ontario

Reason for Participation in U/E Treatment Guidelines Panel

As clinicians at Baycrest and within the community, we continue to struggle with our approach to the hemiplegic arm. We have done our own literature reviews on different aspects of treatment, such as pain management, shoulder supports, prognosis, biofeedback, FES and other effectiveness literature but have always felt that we did not have the whole picture. The development of these guidelines, and hopefully fairly specific guidelines, will be extremely helpful for all physiotherapists, occupational therapists and physicians working in this area.

Dr. Steven L. Wolf (PhD., PT, FAPTA)

Affiliations

- Professor, Rehabilitation Medicine, School of Medicine, Emory University
- Associate Professor, Cell Biology, School of Medicine, Emory University
- Series Editor, Contemporary Perspectives in Rehabilitation, F.A. Davis Co.
- Associate Editor, Canadian Journal of Rehabilitation, Physical Therapy Practice, Journal of Rehabilitation & Health
- Consultant, Catherine Worthingham Fellows Selection Committee, American Physical Therapy Association
- Fellow, Stroke Council, American Heart Association

Research Interests and Activities

- Principal Investigator, Effects of Tai Chi exercise on the frail older subjects
- Investigator, Stroke recovery and caregiver outcomes
- Co-investigator, Training Rehab Scientists: A multidisciplinary approach
- Principal investigator, Movement therapy Evaluation
- Co-investigator, Complementary medicine in neurogenerative disorders

Editorships:

Series Editor, Contemporary Perspectives in Rehabilitation, F.A. Davis Company, Philadelphia, 1985-
Associate Editor, Canadian Journal of Rehabilitation, 1994-
Associate Editor, Physical Therapy Practice, 1990-95
Associate Editor, Journal of Rehabilitation and Health, 1993-
Advisory board Member, Internet Physiotherapy Research Journal, 1995-
Editor, Physiotherapy Research International 1995-2000
Editorial Board, Physical Therapy Reviews, 1996-
Manuscript Reviewer, Journal American Geriatrics Society, 1995-

We are currently exploring the possibility of using both transcranial magnetic stimulation (TSM) and the functional magnetic resonance imaging (MRI) to assess changes in cortical activity during procedures that are designed to force subacute and chronic stroke patients to use their more impaired upper limbs. This approach may provide some insight into the mechanisms responsible for restitution of functional capability in using an impaired limb that had previously not been used to manipulate the environment following a stroke.

Moderator:

Mary Ann O'Brien, MSc, BHSc (PT), (Task Order Coordinator)

Ms. O'Brien is an Assistant Clinical Professor in the School of Rehabilitation Sciences at McMaster University. She was the Task Order Coordinator for the AHRQ Evidence Report on the Management of Chronic Central Neuropathic Pain Following Traumatic Spinal Cord Injury Task Order. Ms. O'Brien has graduate training in the science of conducting systematic reviews and is a licensed physical therapist with extensive clinical experience in rehabilitation. She is a member of the Board of Examiners for the Canadian Physical Therapy Examination. She is also a member of the Cochrane Collaboration Effective Professional Practice and Organization of Care Review Group. Ms. O'Brien has extensive experience in coordinating the production of systematic reviews. Recently, she coordinated the production of 13 systematic reviews of public health interventions for the Ontario government. In addition, she is the author or co-author of 10 systematic reviews in the areas of health professional behavior change, public health, and rehabilitation.

COMMON CLINICAL QUESTIONS

Framing the questions

In developing the clinical questions, five important dimensions were identified: (1) the focus of the consensus exercise (2) a method of classifying motor recovery; (3) the target population with time frames similar to those in the clinical setting; (4) treatment objectives; and (5) the primary and secondary outcomes of interest.

Focus: hemiplegic upper limb

Stage (measured with Chedoke-McMaster Stroke Assessment[1]):

- Early post stoke and low level of motor recovery
- Early post-stroke and high level of motor recovery
- Late post-stroke and low level of motor recovery
- Late post-stroke and high level of motor recovery

A list of recommended valid outcome measures has been provided within this report (Appendix B). For the scenarios questions, the panel selected the Chedoke-McMaster Stroke Assessment (Appendix C) to quantify the degree of motor recovery of the hemiplegic arm and hand. The measure encourages a common language for describing upper limb impairment. The Chedoke-McMaster Assessment expands the original work by Brunnstrom. It classifies motor return into 7 stages and has ongoing evidence of validity[1,2,3,4,5,6,7]. The predictive equations of the Chedoke Assessment permit a high degree of accuracy in determining potential motor recovery.

The equations provided in each scenario were developed to predict individual, risk-adjusted outcomes. They resulted from a prediction study where the prognostic variables with the highest possible statistical significance and predictive validity were identified. Using the predictive equations, the therapist can estimate probable outcomes. These predictions provide information for enhancing clinical judgment (Appendix A).

After calculating each equation, consider the R^2 value. This value explains the amount of variance in the outcome that can be explained by the equation. When the R^2 value is low, caution and judgment should be applied when using this information. However, one can be much more confident in using the equation for arm recovery where 80% of the variance can be explained.

Target population:

- acute hospital setting (0-7 days)
- early rehabilitation (hospital/rehabilitation center/home/outpatients (7-21 days)
- interim rehabilitation (22–60 days)
- later rehabilitation (61-180 days)
- chronic (> 6 months)

Other factors such as the age of the stroke survivor, comorbidities, incidence of previous stroke, and the type of available insurance may result in variations in the target population.

Objective(s) of the intervention:

- prevention and treatment of pain
- minimization of neurological impairment
- optimization of functional recovery
- compensation where the potential to remediate impairments is limited

Specific outcomes of interest:

- Primary outcomes (improved motor and functional recovery, patient satisfaction, quality of life)
- Secondary outcomes (type of care, amount of care, cost of clinical outcomes, economic impact)

For all stroke survivors, patient satisfaction and quality of life are important outcomes.

Clinicians frequently ask which stroke survivor should be treated aggressively and which stroke survivor should be taught compensatory techniques. The following scenarios are "thumb sketches" that attempt to describe key issues commonly encountered in the management of the hemiplegic upper limb. The Consensus Panel recognizes that decision-making is a complex process. A good clinician will address each stroke survivor as an individual and will make treatment decisions based on many factors such as cognition, perception, motor control, motor learning, comorbidities, client goals, financial and community supports. The purpose of these scenarios is to focus on specific issues and strategies that clinicians may recognize within their own practice.

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2. Gowland C, VanHullenaar S, Torresin W, Moreland J, Vanspall B, Barreca S, Ward M,Huijbregts M, Stratford P, Barclay-Goddard R. (1995) Chedoke-McMaster Stroke Assessment: Development, Validation and Administration Manual, McMaster University, School of Rehabilitation Science, Hamilton, ON L8S 4K1

3. Gowland C, Huijbregts M, McLung A, McNern A. (1993). Measuring clinically important change with the Chedoke-McMaster Stroke Assessment. Canadian Journal of Rehabilitation, 7, 14-16.

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Scenario 1: Client with a flaccid upper limb who is at risk for shoulder pain

Flaccid shoulder A 67-year old man is now **7** days post-stroke, having suffered an infarct in the territory of the right middle cerebral artery affecting his non-dominant left arm and hand. No movement can be elicited through various facilitation techniques **(Stage 1)**. He does not realize that he has had a stroke **(anosognosia)** and does not recognize his own hemiplegic limb. He does not complain of shoulder pain; shoulder pain is classified as a **Stage 6.** He has significant sensory and proprioceptive loss in his left arm and hand. There is minimal subluxation of his left gleno-humeral joint. His left hand is edematous. He tends to be restless and impulsive.

Key cues: 7 days post-stroke, flaccid arm, left sided neglect, significant sensory & proprioceptive loss, edematous hand, anosognosia

Question: **What is the optimal treatment to manage the early post-stroke upper limb?**

Outcome focus: prevent shoulder pain, decrease shoulder subluxation, reduce hand edema, maximize motor recovery

Glossary

Stage 1 Arm and Hand[1]

Flaccid paralysis is present. Phasic stretch reflexes are absent or hypoactive. Active movement cannot be elicited reflexively with facilitation or volitionally

Stage 6 Shoulder Pain[1]

No shoulder pain is noted during passive range of motion or with functional activities. One or more of the follow adverse prognostic indicators is present:

- arm in low stage of recovery, Stage 1 or 2
- scapular misalignment
- loss of passive range of shoulder movement with flexion and abduction less than 90 degrees or external rotation less than 60 degrees

Early Rehabilitation 7 days post-stroke

Anosognosia[2] denial of illness

Predictive equation for shoulder pain* (R^2 =.55)[3]

2.33 + (0.44 x 6) + (0.28 x. 1) = **5.3** [CI ±1.6]

shoulder pain arm stage

Predictive outcome for shoulder pain[3]

Shoulder pain, Stage 5 (shoulder pain noted during testing but functional activities not affected by pain) with lower confidence interval for shoulder pain, Stage 4 (constant shoulder pain) and upper confidence interval for shoulder pain, Stage 7 (shoulder pain and prognostic indicators absent).

* see Appendix A, Using the Predictive Equations

2001 Consensus Panel Recommendations for Scenario 1

For stroke survivors with a flaccid upper limb and at high risk for shoulder pain

1. Encourage joint protection and minimize joint trauma

A. emphasize proper positioning, support (Expert Opinion - Strong Consensus; AHCPR's recommendations, 1994[4]) and careful handling of the upper limb during functional activities (Level IV evidence[5])

B. shoulder should not be passively moved beyond 90 degrees of flexion and abduction unless the scapula is upwardly rotated and the humerus is externally rotated (AHCPR recommendations, 1994[4] (Level II evidence[6])

C. inappropriate to use overhead pulleys because they appear to contribute to shoulder tissue injury (Level II evidence[6])

D. use of some means of external support to protect the upper limb (e.g. sling, pocket, by therapist) in Stages 1 or 2 only during transfers and mobility (Expert Opinion - Strong Consensus)

2. Enhance sensory-motor recovery of the upper limb

A. sensory-motor stimulation consisting of passive and active range of movement (Level I Evidence[7,8]) that also includes placement of the upper limb in a variety of positions within the client's visual field (Expert Opinion - Strong Consensus;)

B. electrical stimulation (Level I Evidence[9])

C. visual imagery (Expert Opinion - Strong Consensus)

3. Reduce edema in the hand

A. movement (with neuromuscular stimulation or continuous passive motion (CPM) + upper limb elevation (Level I Evidence[10,11])

B. retrograde massage (Expert Opinion -Strong Consensus)

These recommendations are appropriate for persons at various states of stroke recovery (acute to chronic) who present with the described symptomatology. However, the available evidence specifically supports these recommendations for stroke survivors in the acute hospital or early rehabilitation setting.

Summary for Scenario 1

Recommendations for clients with a flaccid arm and hand and at a high risk for shoulder pain should focus on (1) joint protection, (2) facilitating sensory and motor recovery, and (3) reducing any edema in the post- stroke arm and hand.

References for Scenario 1

1 Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N. (1993) Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment, Stroke, 24, 58-63.

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Scenario 2: Client 4 weeks post-stroke with beginning shoulder pain

Onset of shoulder pain A 60 year old man, **four weeks** post-stroke following a right middle cerebral artery infarct affecting his non-dominant left arm and hand, is receiving interim rehabilitation treatment. He begins to develop shoulder pain that appears to be related to a rotator cuff disorder (e.g. impingement, tendonitis, tear, bursitis). **Shoulder pain** is classified a **Stage 4**; the shoulder pain interferes with his sleeping and ability to dress. **Arm** motor impairment is a **Stage 3** where only 50% of the flexion and extension synergy patterns can be completed. His **hand** is a **Stage 4**. He is able to focus and follow 2 step commands in a quiet setting and exhibits no sign of neglect. Although proprioceptive awareness is intact, discriminative somatosensation is minimally impaired in the affected hand.

Key cues: 4 weeks post-stroke, shoulder pain interfering with sleep and ADL activities; low motor recovery (arm stage 3), mild sensory loss

Question: **What is the optimal therapy recommended to treat the shoulder pain?**

Outcome focus: decrease pain, maintain functional range of movement, maximize motor recovery and functional use

Glossary

Stage 4 Shoulder Pain[2]
Intermittent pain that is present only in the shoulder and interferes with function. The pain is worsened by activity and/or relieved by rest or positioning. Some movement is pain-free; the pain is aggravated from time to time. Occasionally the client cannot participate in the regular rehabilitation program or daily activities because of the pain.

Stage 3 Arm[1]
Spasticity is marked. The synergistic movements can be elicited voluntarily but are obligatory.

Stage 4 Hand [1]
Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movements combining antagonistic synergies can be performed when the prime moves are the strong components of the synergy.

Interim rehabilitation: 28 days post-stroke

Predictive equation for shoulder pain (R^2 =.55)[2]

2.33 + (0.44 x 4) + (0.28 x 3) = **4.9** [CI ±1.6]

arm stage

Predictive outcome for shoulder pain[2]

Shoulder pain, Stage 5 (shoulder pain noted during testing but functional activities not affected by pain) with a lower confidence interval of shoulder pain being Stage 3 (constant pain in the shoulder) and an upper confidence interval of shoulder pain being Stage 7 (no shoulder pain).

Predictive Equation for Arm Motor Recovery2 (R2 =.80)

0.82 + (1.03 x 3) - (0.03 x 4) = **3.8** [±1.5]

arm stage weeks

Predictive outcomes for motor recovery for the arm[2]

Strong possibility of achieving a Stage 4 arm, with an upper confidence interval of Stage 5 (synergy patterns can be reversed even if the movement takes place in the strongest synergy, flexion, first)

Predictive Equation for Hand Motor Recovery[2] (R^2 = .78)

0.53 + (0.98 x 4) = **4.5**[±1.5]

hand stage

Predictive outcomes for motor recovery for the hand[2]

Possibility of a Stage 5 hand with an upper confidence interval of Stage 6 (where coordination and patterns of movement are near normal. Abnormal patterns of movement with faulty timing emerge when rapid or complex actions are requested).

2001 Consensus Panel Recommendations for Scenario 2

For stroke survivors with sensory-motor impairments and the onset of shoulder pain that interferes with sleep and activities of daily living

1. **Identify factors that exacerbate (or cause) shoulder pain (**Expert Opinion -Strong Consensus)

2. **Apply orthopedic principles that take into account central nervous system control, soft tissue factors and active and passive movement elements[4]. These principles may be adapted for the post-stroke shoulder to treat the rotator cuff component of the shoulder pain.** They include the use of modalities to prepare the connective tissues for stretching, gentle grade 1-2 joint mobilizations for accessory movements at the shoulder complex, gentle connective tissue stretching. (Expert Opinion - Strong Consensus)

3. **Treat the shoulder pain and sensory-motor impairment** (Expert Opinion Strong Consensus)
   A. pharmacological management
   B. respect the pain (e.g. have the client perform active or active assisted movement within the pain-free range, avoid those activities that increase the pain, position and support the limb to minimize pain, protect the limb during functional mobility tasks)
   C. teach the client to respect the pain
   D. facilitate active movement of the upper limb and trunk
   E. optimize functional recovery

These recommendations are appropriate for persons at various stages of stroke recovery (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the early and/or interim phase of rehabilitation.

The summary report of the effectiveness literature for the post-stroke arm and hand[3] did not reveal any intervention studies that addressed the management of the early onset of shoulder pain in a stroke survivor with low motor recovery. Therefore, expert opinion has been given.

Summary for Scenario 2

Recommendations for a rehabilitation client who begins to develop shoulder pain due to a rotator cuff disorder (e.g. impingement, tendonitis, tear, bursitis) focus on (1) identification of the factors that either cause or exacerbate the shoulder pain and (2) treatment using a variety of modalities, gentle grade 1-2 joint mobilizations, pharmacological management, education, and facilitation of active movement in the upper limb and trunk.

References for Scenario 2

1. Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N.(1993) Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment, Stroke, 24, 58-63.

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3. Barreca, S. Summary of the Effectiveness Literature on the Hemiplegic Arm and Hand. Prepared for the Consensus Exercise on the Management of the Post-stroke Arm and Hand, June 2001

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Scenario 3: Client 6 weeks post-stroke with moderate shoulder pain

Onset of shoulder pain A 67 year old man, **six weeks** post-stroke following a right middle cerebral artery infarct affecting his non-dominant left arm and hand, begins to develop shoulder pain. He has a pure motor stroke, with normal somatosensation and proprioception. Shoulder pain is a **Stage 3**; the shoulder pain interferes with his sleeping and the functional use of his upper limb. He complains of pain when pulling on his t-shirt, drying his back, and reaching for items. Pain is aggravated by active shoulder flexion/elevation above 90 degrees. He is unable to abduct his shoulder without hiking his scapula. The scapular spine is elevated while the inferior angle abducted. Arm motor impairment is a **Stage 4** where he can move from flexion synergy into extension synergy. The stage of his hand is a **Stage 3**. He is able to follow 3-step instructions and attends to his left side.

Key cues: 6 weeks post-stroke, shoulder pain interfering with sleep, moderate motor recovery (Stage 4), abducted and elevated scapula, cognitively alert.

Question: What is the optimal therapy recommended to treat motor impairments and shoulder pain in this client?

Outcome focus: eliminate pain, achieve adequate and pain-free range of movement, optimize motor recovery and functional use

Glossary

Stage 3 Shoulder pain[2]
Constant pain in the shoulder that interferes with a stroke survivor's ability to participate in the regular rehabilitation program or to carry out functional activities. Movement, positioning or rest does not relieve the pain. The client complains of pain while dressing or undressing.

Stage 4 Arm[1]
Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movements combining antagonistic synergies can be performed when the prime moves are the strong components of the synergy.

Stage 3 Hand[1]
Spasticity is marked. The synergistic movements can be elicited voluntarily but are obligatory.

Interim rehabilitation: 6 weeks post-stroke

Predictive equation for shoulder pain (R^2 =.55)[2]

$$2.33 + (0.44 \times 3) + (0.28 \times 4) = \mathbf{4.8}\ [CI \pm 1.6]$$

shoulder pain — arm stage

Predictive outcome for shoulder pain[2]
Strong Possibility of shoulder pain Stage 5 (shoulder pain noted during testing but functional activities not affected by pain) with a lower confidence interval of shoulder pain being Stage 3 (constant shoulder pain) and an upper confidence interval being Stage 6 (no shoulder pain but one prognostic indicator present).

Predictive Equation for Arm Motor Recovery2 (R2 =.80)

0.82 + (1.03 x 4) - (0.03 x 6) = **4.8** [±1.5]

arm stage weeks

Strong possibility of a Stage 5 with upper confidence interval of Stage 6 (where coordination and patterns of movement are near normal. Abnormal patterns of movement with faulty timing emerge when rapid or complex actions are requested).

Predictive Equation for Hand Motor Recovery2 (R2 = .78)

0.53 + (0.98 x 3) = 3**.5** [±1.5]

hand stage

Possibility of a Stage 4 with upper confidence interval of Stage 5 (synergy patterns can be reversed even if the movement takes place in the strongest synergy, flexion, first)

2001 Consensus Panel Recommendations for Scenario 3

For stroke survivors with moderate motor recovery and an onset of shoulder pain that interferes with sleep and activities of daily living

1. **Identify task or movement characteristics that increase shoulder pain** (Expert Opinion - Strong Consensus)

2. **Apply orthopedic principles that take in account central nervous system control, soft tissue factors, and active and passive movement elements[3]. These principles may be adapted for the post-stroke shoulder to treat the rotator cuff component of the shoulder pain** They include the use of modalities to prepare the connective tissues for stretching, gentle grade 1-2 joint mobilizations for accessory movements at the shoulder complex, gentle connective tissue stretching. (Expert Opinion - Expert Consensus)

3. **Treat the shoulder pain & sensory-motor impairment** (Expert opinion-Strong Consensus)
   A. pharmacological management
   B. grade motor tasks and gently increase active and passive range of motion
   C. respect the pain during movement and positioning (e.g. work within the pain-free range, avoid those activities that increase the pain)
   D. teach the client to respect pain during movement
   E. instruct positioning to reduce pain while sleeping
   F. facilitate active movement of the upper limb and trunk

4. **Task specific movement must take into account the symptomatology and movement characteristics of the stroke survivor.** (Expert Opinion - Strong Consensus)

5. **There is contrary opinion as to whether manual guidance will correct movement abnormalities at this stage of motor recovery** (Expert Opinion -Strong Consensus)**. If the client is unable to engage in task specific training due to pain, manual guidance may be used.** (Expert Opinion - Strong Consensus)

6. **It is inappropriate to use overhead pulleys. Pulleys appear to contribute to shoulder tissue injury** (Level II evidence[4])

These recommendations are appropriate for persons at various stages of stroke recovery (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the early or interim phase of rehabilitation.

Summary for Scenario 3

Recommendations for a rehabilitation client who begins to develop shoulder pain due to a rotator cuff disorder (e.g. impingement, tendonitis, tear, bursitis) focus on (1) identification of the factors that either cause or exacerbate the shoulder pain; (2) treatment using a variety of modalities, gentle mobilizations, pharmacological management, and education; (3) the evaluation of the movement capabilities during task specific actions; and (4) the avoidance of overhead pulleys.

The panel is divided in their opinion as to whether manual guidance will correct abnormal movements at this stage of motor recovery. However, there is strong consensus that if the client is unable to perform task specific training due to pain, manual guidance may be given.

References for Scenario 3

1. Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N.(1993) Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment, Stroke, 24, 58-63.

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3 Panjabi, M.M. (1992) The Stabilizing System of the Spine. Part 1. Function, Dysfunction, Adaptation, and Enhancement. Journal of Spinal Disorders, 5,4, 383-389.

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Scenario 4: Client 2 months post-stroke with residual shoulder pain

Onset of shoulder pain A 54 year old woman, **two months** post-stroke following a **lacunar** infarct in the territory of the left middle cerebral artery affecting her dominant right arm and hand, complains of an intermittent, nagging discomfort in her shoulder which worsens during the day with more use; shoulder pain is classified as a **Stage 4**. The tasks that contribute to shoulder pain are working on the computer, getting dishes out of the cupboard, carrying the laundry, ironing, and gardening. Right arm and hand are both a **Stage 6**. She lacks the last 20 degrees of active full flexion /elevation at the shoulder. Shoulder abduction is full, with a subtle irregular scapular gleno-humeral rhythm. She is able to use her right hand as her dominant extremity with only occasional difficulty during fine motor tasks. She exhibits no cognitive impairments during functional activities, attends well to instructions, and demonstrates no perceptual or sensory deficits.

Key cues: younger stroke survivor, 8 weeks post-stroke, nagging discomfort in her dominant shoulder with continual use, high motor recovery (Stage 6), high cognitive functioning

Specific question: What is the therapy recommended to optimize motor recovery and reduce shoulder pain?

Outcome focus: eliminate pain, optimize motor recovery and functional use

Glossary

Lacunar small infarct

Interim Rehabilitation 60 days post-stroke

Stage 4 Shoulder pain[2]

Shoulder pain that intermittently interferes with function. The pain can be worsened by activity or relieved by rest or positioning. Some movement is pain-free; the pain is aggravated from time to time.

Stage 6 Arm & Hand[1]

Coordination and patterns of movement are near normal. Spasticity demonstrated by resistance to passive movement is no longer present. A large number of environmentally specific patterns of movements are now possible. Abnormal patterns of movement with faulty timing emerge when rapid or complex actions are requested.

Predictive equation for shoulder pain (R^2 =.55)[2]

2.33 + (0.44 x 4) + (0.28 x 6) = **5.8** CI ±1.6]

shoulder pain | arm stage

Predictive outcome for shoulder pain[2]

Strong possibility of a Stage 6 (no shoulder pain but one prognostic indicator present) with a lower confidence interval of shoulder pain, Stage 4 (intermittent shoulder pain) and with an upper confidence interval, Stage 7 (no shoulder pain).

Predictive Equation for Arm Motor Recovery2 (R2 =.80)

0.82 + (1.03 x 6) - (0.03 x 8) = **6.8** [±1.5]

arm stage weeks

Predictive Equation for Hand Motor Recovery2 (R2 = .78)

0.53 + (0.98 x 6) = **6.4** [±1.5]

hand stage

Predictive Stage of Motor Recovery for the Arm and Hand

Stage 7 Normal. A "normal" variety of rapid, age appropriate complex movement patterns are possible with normal timing, coordination, strength and endurance.

2001 Consensus Panel Recommendations for Scenario 4

For stroke survivors with a high level of motor recovery and the onset of shoulder pain that interferes with daily activities

1. **Identify the movement and task characteristics that contribute to shoulder pain** (Expert Opinion- Strong Consensus)
2. **Provide pharmacological management for the treatment of pain** (Expert Opinion- Strong Consensus)
3. **Establish a monitored home program that emphasizes self-pacing and the use of ergonomic principles during functional activities.** (Expert Opinion- Strong Consensus)
4. **Teach the client to respect the pain during movement, exercise, strengthening, and task performance as related to the stroke survivor's functional needs.** (Expert Opinion - Strong Consensus)

These recommendations are appropriate for persons at various stages of stroke recovery (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the interim or later phase of rehabilitation.

The summary report of the effectiveness literature for the post-stroke arm and hand[3] did not reveal any intervention studies that addressed the management of the early onset of shoulder pain in a stroke survivor with high motor recovery. Therefore, expert opinion has been given as no relevant evidence is available.

Summary for Scenario 4

Recommendations for stroke survivors with a high level of motor recovery who experience shoulder pain focus on (1) identification of the movement or tasks that contribute to pain; (2) pharmacological treatment; (3) establishing a home therapeutic program; and (4) teaching the client to respect the pain during various movements, exercises, and task performances.

References for Scenario 4

1 Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N.(1993) Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment, Stroke, 24, *58-63.*

2. Gowland C, VanHullenaar S, Torresin W, Moreland J, Vanspall B, Barreca S, Ward M, Huijbregts M, Stratford P, Barclay-Goddard R. (1995) Chedoke-McMaster Stroke Assessment: Development, Validation and Administration Manual, *M*cMaster University, School of Rehabilitation Science, Hamilton, ON L8S 4K1

3. Barreca, S. Summary of the Effectiveness Literature on the Hemiplegic Arm and Hand. Prepared for the Consensus Exercise on the Management of the Post-stroke Arm and Hand, June 2001

Scenario 5: Client 4 weeks post-stroke with severe cognitive, sensory & motor impairments

Management of the upper limb A 65 year old woman, **4 weeks** post-stroke following a right middle cerebral artery infarct affecting her non-dominant left arm and hand, has severe motor, sensory, and cognitive deficits. She neglects her left side and does not know where her arm is in space. Noise and sudden movement easily distract her. Motor impairment of the arm and hand is a **Stage 2** where tone is present but there is no volitional movement within synergy patterns. She requires at least moderate assistance to complete self-care activities and functional mobility/transfers, and does not attempt to use her left arm as a stabilizer during bilateral tasks.

Key cues: low motor recovery (Stage 2), hemiplegia of left, non-dominant arm with severe neglect, sensory, and cognitive deficits

Specific questions: 5a) What is the optimal treatment for those stroke survivors who are predicted to do poorly (have severe motor, sensory, and cognitive deficits)? 5b) More specifically, should the main purpose of treatment be compensatory or remedial?

Outcome focus: prevent pain, maintain passive range of movement, maximize functional performance during activities of daily living through compensation, educate family or caregiver

Glossary

Stage 2 Arm and Hand[1]
Spasticity is present and is felt as resistance to passive movement. No voluntary movement is present but facilitation will elicit the limb synergies reflexively.

Interim Rehabilitation: 28 days post-stroke

Predictive Equation for Arm Motor Recovery2 (R2 =.80)

$$0.82 + (1.03 \times 2) - (0.03 \times 4) = \mathbf{2.8}\ [\pm 1.5]$$

(2: arm stage; 4: weeks)

Predictive Equation for Hand Motor Recovery2 (R2 = .78)

$$0.53 + (0.98 \times 2) = \mathbf{2.5}\ [\pm 1.5]$$

(2: hand stage)

Predictive outcomes for motor recovery for the arm and hand

Possibility of achieving a Stage 3 arm and hand, with an upper confidence interval of Stage 4 (synergy patterns can be reversed if movement takes place in the weaker synergy (extension) first; movements combining antagonistic synergies can be performed if the prime movers are the strong component of the synergy)

2001 Consensus Panel Recommendations for Scenario 5

For the client with severe motor, sensory, and functional deficits in the involved limb after stroke, the effectiveness literature [3] indicates that additional treatment for the upper limb will not result in any significant neurological change The evidence to date suggests that interventions may not lead to meaningful functional use of the affected limb at this stage of motor recovery[4,5,6] (Level I evidence).

1. **Maintain a comfortable, pain-free, mobile arm and hand**
   A. emphasize proper positioning, support (Expert Opinion - Strong Consensus; AHCPR recommendations, 1994[7]) while at rest and careful handling of the upper limb during functional activities (Level IV evidence[8])
   B. engage in classes overseen by professional rehabilitation clinicians in an institutional or community setting that teach the client and caregiver to perform self-range of motion exercises (Expert opinion -Strong Consensus)
   C. encourage caretaker-supervised self-range of motion exercises in the home (Expert Opinion -Strong Consensus)
   D. avoid the use of overhead pulleys that appear to contribute to shoulder tissue injury (Level II evidence[9])
   E. use some means of external support for the upper limb (e.g. sling, pocket, held by the therapist) in Stages 1 or 2 during transfers and mobility (Expert Opinion -Strong Consensus)
   F. place the upper limb in a variety of positions that include placing arm and hand within client's visual field (Expert Opinion -Strong Consensus)
   G. use some means of external support to protect the upper limb during wheelchair use (e.g. hemi tray, arm trough (Expert Opinion -Strong Consensus)

2. **To maximize functional independence, stroke survivors with persistent motor and sensory deficits and their caregivers should be taught compensatory techniques[7] and environmental adaptations that enable performance of important tasks and activities with the less affected arm and hand**

These recommendations are appropriate for persons at various times in the stroke recovery process (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the interim or later phase of rehabilitation.

Summary for Scenario 5

For the client with severe motor, sensory, and functional deficits in the involved limb, the recommendations focus on (1) maintaining a comfortable, mobile arm and hand and (2) maximizing functional independence through compensatory techniques and environmental adaptation.

References for Scenario 5

1. Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N.(1993). Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment, Stroke, 24, 58-63.

2. Gowland C, VanHullenaar S, Torresin W, Moreland J, Vanspall B, Barreca S, Ward M, Huijbregts M, Stratford P, Barclay-Goddard R. (1995). Chedoke-McMaster Stroke Assessment: Development, Validation and Administration Manual, *M*cMaster University, School of Rehabilitation Science, Hamilton, ON L8S 4K1

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8. Braus, D. F., Krauss, J. K., & Strobel, J. (1994). The shoulder-hand syndrome after stroke: a prospective clinical trial. (Part 11) Ann.Neurol., 36, 728-733.

9. Kumar, R., Metter, E. J., Mehta, A. J., & Chew, T. (1990). Shoulder pain in hemiplegia: the role of exercise. American Journal of Physical Medicine & Rehabilitation, 69, 205-208.

Scenario 6: Client 1 year post-stroke with moderate motor impairments

Management of the upper limb A 70 year old man, **one-year** post-stroke following a right middle cerebral artery infarct, wants to use his dominant affected arm and hand more. He has never received intense upper limb retraining. Motor impairment for the arm and hand is **Stage 4.** He can extend his wrist 20 degrees, extend his metacarpals 10 degrees and flex his fingers ¾ range of movement. He can touch his chin, shrug his shoulder, flex his shoulder to 90 degrees, and fully supinate. He is cognitively alert, walking 200 meters with a small-based quad cane, and independent in basic activities of daily living using compensatory techniques. Somatosensation and proprioception are minimally affected.

Key cues: motivated, cognitively alert, moderate motor impairment (Stage 4), some active wrist & finger extension in dominant hand, minimal sensory loss, no previous intensive upper limb therapy

Specific questions: 6a) Is therapy intervention appropriate for clients with moderate chronic motor impairments? If so, should the main purpose of treatment be compensatory or remedial? 6b) If the main purpose of treatment should be remedial, should treatment focus on decreasing motor impairment through exercise or enhancing functional use of the involved limb?

Outcome focus: optimize functional use of the involved limb

Glossary

Stage 4 Arm and Hand[1]
Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movements combining antagonistic synergies can be performed when the prime moves are the strong components of the synergy.

Chronic 1-year post-stroke

Predictive equations not applicable to a stroke survivor one-year post-stroke as the original research was conducted on stroke survivors less than 3 months post onset

2001 Consensus Panel Recommendations for Scenario 6

For clients with moderate motor impairments who demonstrate high motivation and potential for functional motor gains

1. **Engage in repetitive and intense use of novel tasks that challenge the stroke survivor to acquire necessary motor skills to use the involved upper limb during functional tasks and activities**[2,3] (Level II evidence)

2. **Engage in motor learning training**[4,5](Level III evidence**) including the use of imagery (for example, mental rehearsal to improve upper limb motor function**[6,7] (Level II evidence).

These recommendations are appropriate for persons at various stages of stroke recovery (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the later phase of rehabilitation who demonstrate cognitive flexibility[8,9]. Consideration should be given to providing therapy in group programs versus individual sessions in out patient departments or engaging client in a supervised home program.

Summary for Scenario 6

Recommendations for stroke survivors with moderate impairment, who demonstrate a potential for functional gains, focus on (1) repetitive and intense use of novel tasks and (2) motor learning training to maximize recovery.

References for Scenario 6

1. Gowland C, Stratford P, Ward M, Moreland J, Torresin W, VanHullenaar S, Sanford J, Barreca S, Vanspall B, and Plews, N.(1993).Measuring Physical Impairment and Disability with the Chedoke-McMaster Stroke Assessment. Stroke, 24, 58-63.

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9. Barreca S, Finlayson MAJ, Gowland C,& Basmajian JV (1999). Use of the Halstead Category Test as a cognitive predictor of functional recovery in the hemiplegic upper limb: A cross-validation study. The Clinical Neuropsychologist ,13, 171-181.

Scenario 7: Client 3 weeks post-stroke with severe motor impairments

Management of the upper limb A 60 year old man has been transferred to a rehabilitation hospital following an infarct in the territory of the left middle cerebral artery **three weeks** ago. He is right-hand dominant. He has **Broca's aphasia** but is cognitively bright, able to follow simple instructions well, and extremely motivated. Somatosensation and proprioception are minimally impaired. There are moderate signs of **ideomotor apraxia**. He requires minimal assistance to perform self-care tasks, particularly those involving utensil use or fine motor dexterity requiring the use of affected or both limbs. He is walking 25 meters with a small-based quad cane and one person giving minimal assistance. Arm and hand are a **Stage 2**, where he is unable to complete full range of either the extensor or flexor synergy patterns. He has a non-painful shoulder subluxation.

Key cues: 3 weeks post-stroke, motivated, cognitively alert, ideomotor apraxia, low motor recovery, non-painful shoulder subluxation

Specific questions: 7a) Should treatment focus on decreasing impairment or improving functional abilities or both? 7b) Should the main purpose of treatment at this phase of recovery be remedial or compensatory? Specifically, should treatment focus on enhancing functional movement of the involved limb or teaching compensatory techniques?

Outcome focus: optimize functional abilities, control subluxation, prevent pain

Glossary

Broca's aphasia[1]

Characterized by awkward articulation, restricted vocabulary, and restriction to simple grammatical forms, in the presence of a relative preservation of auditory comprehension.

Stage 2 Arm and Hand [2]

Spasticity is present and is felt as resistance to passive movement. No voluntary movement is present but facilitation will elicit the limb synergies reflexively.

Ideomotor apraxia[3]

The inability to imitate gestures or perform a purposeful motor task on command even though the patient fully understands the idea or concept of the task.

Predictive Equation for Arm Motor Recovery4 (R2 =.80)

0.82 + (1.03 x 2) - (0.03 x 3) = **2.8** [±1.5]

arm stage weeks

Predictive Equation for Hand Motor Recovery4 (R2 = .78)

0.53 + (0.98 x 2) = **2.5** [±1.5]

hand stage

Predictive outcomes for the arm and hand

Possibility of achieving a Stage 3 arm and hand, with an upper confidence interval of Stage 4 (synergy patterns can be reversed if movement takes place in the weaker synergy (extension) first; movements combining antagonistic synergies can be performed if the prime movers are the strong component of the synergy)

2001 Consensus Panel Recommendations for Scenario 7

For the client with severe motor, sensory, and functional deficits in the involved limb after stroke, the effectiveness literature [5] indicates that additional treatment for the upper limb will not result in any significant neurological change [4,5,6]. The evidence to date suggests that remedial interventions used will not lead to meaningful functional use of the affected limb at this stage of motor recovery.[4,5,6,7,8](Level I evidence).

1. **Maintain a comfortable, pain-free, mobile arm and hand**
   A. emphasize proper positioning, support (Expert Opinion -Strong Consensus; AHCPR recommendations, 1994[9]) and careful handling of the upper limb during functional activities (Level IV evidence[10])
   B. engage in classes overseen by professional rehabilitation clinicians in an institutional or community setting that teach the client to perform self-range of motion exercises (Expert Opinion -Strong Consensus)
   C. if the client requires assistance, caretaker supervised self-range of motion exercises in the home (Expert opinion -Strong Consensus)
   D. avoid the use of overhead pulleys that appear to contribute to shoulder tissue injury (Level II evidence[11])

2. **To maximize functional independence, stroke survivors with severe sensorimotor and functional deficits should be taught compensatory techniques[9] and environmental adaptations that enable performance of important tasks and activities with the less affected arm and hand**

3. **Electrical stimulation[12]** (Level I evidence) **unlike slings[13]**(Level III evidence) **may reduce shoulder subluxation in the short term (i.e. mean 5 weeks). Long term follow-up has failed to demonstrate further improvement in minimizing subluxation[14]**(Level III evidence)

These recommendations are appropriate for persons at various stages of stroke recovery (acute to chronic) who present with the described symptomatology. However, the evidence specifically supports the use of these recommendations with clients in the interim phase of rehabilitation.

Summary for Scenario 7

For stroke survivors with severe motor, sensory, and cognitive deficits, the recommendations focus on (1) the maintenance of a comfortable, mobile arm and hand; (2) optimal functional independence through compensatory techniques and environmental adaptations, and (3) the use of electrical stimulation to the shoulder to reduce subluxation.

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Scenario 8: Clients 5 weeks post-stroke with high level of motor return

Management of the upper limb A 60 year old woman attends outpatient therapy following an infarct in the territory of the left middle cerebral artery **five weeks** ago affecting her right dominant upper limb. She is independent in ambulation with a single point cane. She demonstrates **ideomotor apraxia** during less frequently performed functional tasks such as wrapping a present or folding a letter to place it in an envelope. Her **arm** is a **Stage 5** where she is able to reverse movement of her arm from the flexion synergy into the extension. Her shoulder is pain-free. Her **hand** is a **Stage 4,** where she is able to make a fist, adduct her thumb, and almost fully extend her fingers (more than 1/2 range). The metacarpals and inter-phalangeal joints of her right hand are swollen and stiff.

Key cues: cognitively bright, moderate to good motor recovery, edema in fingers of affected hand, mild ideomotor apraxia

Specific questions: 8a) Should the main purpose of treatment be compensatory or remedial? 8b) If the main purpose of treatment should be remedial, should treatment focus on decreasing motor impairment through exercise or enhancing functional use of the involved limb?

Outcome focus: optimize motor & functional recovery, decrease hand edema

Glossary

Stage 5 arm[1]
Spasticity wanes, but is evident with rapid movement and at the extremes of range. Synergy patterns can be reversed even if the movement takes place in the strongest synergy first. Movement can be performed by utilizing the weak components of both synergies as prime movers. Most movements become environmentally specific.

Stage 4 Hand [1]
Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movements combining antagonistic synergies can be performed when the prime movers are the strong components of the synergy.

Ideomotor apraxia[2]
The inability to imitate gestures or perform a purposeful motor task on command even though the patient fully understands the idea or concept of the task.

Predictive Equation for Arm Motor Recovery3 (R2 =.80)

$$0.82 + (1.03 \times 5) - (0.03 \times 5) = \mathbf{5.8}\ [\pm 1.5]$$

(1.03 × 5): arm stage; (0.03 × 5): weeks

Predictive Equation for Hand Motor Recovery2 (R2 = .78)

$$0.53 + (0.98 \times 4) = \mathbf{4.4}\ [\pm 1.5]$$

(0.98 × 4): arm stage

Predictive outcomes for the arm and hand

Possibility of achieving a Stage 6 for the arm and Stage 4 for the hand with an upper confidence interval of a Stage 7 (" normal") for the arm and Stage 6 for the hand (where coordination and patterns of movement are near normal. Abnormal patterns of movement with faulty timing emerge when rapid or complex actions are requested.)

2001 Consensus Panel Recommendations for Scenario 8

For clients with moderate motor recovery and edema of the affected arm and hand

1. **Reduce motor impairment and improve functional motor recovery**
   A. sensory-motor training[4,5,6,7](Level I evidence)
   B. EMG-electrical stimulation of the wrist and forearm[8,9,10] (Level I evidence)
   C. electrical stimulation of the wrist and forearm[11, 12] (Level I evidence)
   D. engage in repetitive and intense use of novel tasks that challenge the stroke survivor to acquire necessary motor skills to use the involved upper limb during functional tasks and activities[13,14](Level I evidence)

2. **To reduce hand edema**
   A. active self-range of movement of wrist, fingers, and thumb to gain full range of movement (Expert Opinion - Strong Consensus)
   B. gentle grade 1 -2 mobilizations for accessory movements of the hand and fingers (Expert Opinion - Strong Consensus)
   C. retro-grade massage by client (Expert Opinion - Strong Consensus)
   D. active movement in conjunction with elevation (Expert Opinion - Strong Consensus)
   E. cold water immersion[15] (Level III evidence) or contrast baths (Expert Opinion -Strong Consensus)

These recommendations are appropriate for stroke survivors who are at various phases of rehabilitation who present with the described symptomatology.

Summary for Scenario 8

For stroke survivors with moderate motor recovery, the recommendations focus on (1) reducing motor impairment and optimal functional recovery through the use of repetitive novel tasks, sensory-motor training, and biofeedback-electrical stimulation of the wrist and fingers, and (2) reducing hand edema through a variety of techniques such as massage, active exercises and range of movement, limb elevation, cold water therapy, and contrast baths.

References for Scenario 8

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Scenario 9: Client 4 months post-stroke discharged from therapy

Economic and societal costs: A 48- year old stroke survivor, **4 months** post-stroke following an infarct into the territory of his left middle cerebral artery, has been discharged from therapy. He is able to walk 900 meters with a single point cane. He is independent in his self-care using compensatory techniques. His **arm** is a **Stage 4** and his dominant **hand** is a **Stage 2**. **Shoulder pain** is a **Stage 5**. He has moderate sensory and proprioceptive deficits. He worked as a computer analyst. His main hobby was belonging to a model train club where he designed tracks, villages and built the models. He is unable to pursue his previous employment or hobby.

Specific questions

9a) What are the economic and societal costs (to the health care system, to the individual client, to the caregiver or family) in failing to address the management of the hemiplegic arm and hand to the satisfaction of the client? 9b) Is there an economic or societal benefit in trying to treat the hemiplegic upper limb over not treating the post-stroke arm and hand? 9c) What is a reasonable amount of intervention to satisfy a stroke survivor whose hemiplegic arm and hand is not going to improve functionally? 9d) What is a reasonable amount of intervention to satisfy a client whose hemiplegic arm and hand is going to improve functionally?

Key cues non-functional use of upper limb, unemployed, unable to pursue hobby,

Outcomes

- societal costs such as alterations of life roles and tasks, quality of life, patient satisfaction, caregiver burden and potential changes in caregiver roles and responsibilities
- economic costs such as amount of care, cost of human resources, economic impact to individual, family unit, health care system

Glossary

Stage 4 Arm

Spasticity decreases. Synergy patterns can be reversed if movement takes place in the weaker synergy first. Movements combining antagonistic synergies can be performed when the prime movers are the strong components of the synergy.

Stage 2 Hand

Spasticity is present and is felt as resistance to passive movement. No voluntary movement is present but a facilitatory stimulus will elicit the limb synergies reflexively.

Stage 5 Shoulder Pain

Shoulder pain is noted during testing but the pain does not affect normal functional activities.

Predictive Equation for Arm Motor Recovery3(R2 =.80)

$$0.82 + (1.03 \times 4) - (0.03 \times 16) = \mathbf{4.5}\ [\pm 1.5]$$

(4: arm stage; 16: weeks)

Predictive Equation for Hand Motor Recovery2 (R2 = .78)

$$0.53 + (0.98 \times 2) = \mathbf{2.5}\ [\pm 1.5]$$

(2: arm stage)

Predictive outcomes for the arm and hand

Possibility of achieving a Stage 5 arm and a Stage 3 hand, with an upper confidence interval of Stage 6 (where coordination and patterns of movement are near normal) and a Stage 4 for the hand (where synergy patterns can be reversed if movement takes place in the weaker synergy first).

2001 Consensus Panel Recommendations for Scenario 9

For clients who do not have functional use of their upper limb which interferes with their ability to resume occupational tasks and roles

1. **research is needed to determine and quantify the economic and societal costs that are incurred**

APPENDIX A

Using the Predictive Equations of the Chedoke-McMaster Stroke Assessment

Three separate predictive equations or formulae were used to deal with clinical problems commonly seen in the management of the hemiplegic upper limb. These predictive equations were developed by the Chedoke-McMaster Stroke Research Team to address treatment planning and risk-adjusted outcomes for stroke survivors who are in the rehabilitation phase of their recovery. These equations were used during the consensus exercise because they provide an useful guideline to predict statistically significant outcomes for (a) the amount of pain in the hemiplegic shoulder; (b) the degree of motor recovery in the hemiplegic arm; and (c) the degree of motor recovery in the hemiplegic hand.

Motor recovery in the hemiplegic upper limb is highly predictable. These predictive equations, with R^2 values that range between 0.72-0.8, represent a powerful tool in clinical decision- making. What exactly do we mean by an R^2 value? Stated simply, R^2 is the agreement between all the independent predictor variables and the dependent value. The value for R^2 varies only from 0 to 1. For the predictive arm equation, the R^2 is 0.8 meaning that the two independent predictor variables, the admission arm stage and time post-stroke, explain 80% of the variability in the dependent variable, the predicted arm stage. Similarly, for the predictive hand equation, the R^2 is 0.72, so that the initial hand stage and time post-stroke explain 72% of the variability in the predicted hand stage. As the strength of the relationship between the predictor variables and the dependent variables in these two predictive equations is strong, clinicians may feel confident to calculate and use the risk-adjusted outcomes for upper limb motor recovery in their treatment planning.

Often clinicians ask how we determined which independent variables are the most important predictors of outcome? The predictive literature was thoroughly searched and the significant prognostic indicators were entered into a statistical program, SPSS. A series of multiple regression analyses were performed. The purpose of a multiple regression is to maximize the accuracy of the predictions while minimizing the number of variables in the equations. Variables are retained in an equation only if they significantly improve the R^2, the coefficient of determination. Our multiple regression analyses revealed that the one or two predictors in the three separate upper limb equations are robust enough to strongly determine pain and motor outcomes.

Let us look at the predictive equation for shoulder pain in Scenario 1. We now understand that the R^2 explains 55% of the variability of the predicted shoulder pain but what do the other numbers mean?

The general prediction equation for multiple regression is based on the equation for a straight line, where you try to find the best fit between X and Y, or between the independent variables and your outcome of interest.

The equation for a straight line is $Y = a + b_1 X_1 + b_2 X_2$ where

Y = predicted outcome
a = constant intercept (the Y value at the point where the line intersects the Y axis)
b_1 = beta -weight or slope of the first independent variable (X_1)
b_2 = beta- weight or slope of the second independent variable (X_2)

In the first scenario, a client is admitted to hospital with a flaccid hemiplegic arm and hand (Stage 1 as measured by the Chedoke-McMaster Stroke Assessment). He does not complain of shoulder pain but his low motor recovery places him at risk for developing pain in the future (Stage 6). Putting these two numbers into the predictive equation, we can now determine the risk-adjusted outcome for shoulder pain for this gentleman. Our calculations tell us that this client's affected shoulder is predicted to become a Stage 5 (when the first decimal point is less than 0.5) where he may experience pain in his shoulder with testing but will able to perform functional activities without shoulder pain.

Predictive equation for shoulder pain (R2 =.55)

2.33 + (0.44 X 6) + (0.28 X 1) = **5.3** [CI ±1.6]

⇩ ⇩ ⇩ ⇩ ⇩ ⇩ ⇩

constant intercept | beta weight | initial shoulder pain risk for | beta weight | initial arm stage | predicted shoulder pain | confidence interval

Because we know that this prediction is not going to be exact, we can provide additional helpful information by generating a confidence interval around the predicted value. A confidence interval is a range of scores around a mean (or average) sum of all scores that represents a certain probability that the true mean is within this range. Confidence intervals are expressed as a plus or minus value (±) that gives an upper and lower confidence level. The confidence interval for the above formula for shoulder pain would add or subtract a whole motor stage (1.6) to the predicted Y value (5.3). Thus, we could be 95% certain that our stroke survivor in Scenario 1, with shoulder pain at admission classified as a Stage 6, would have a predicted stage of shoulder pain between Stages 4-7. The confidence interval tells us that there is an equal chance that the client will have no complaints of shoulder pain (Stage 7) or that the client will experience severe, intermittent shoulder pain (Stage 4). As a consequence of risk-adjusted outcomes, we would likely want to implement a shoulder pain management program to decrease the possibility of shoulder pain.

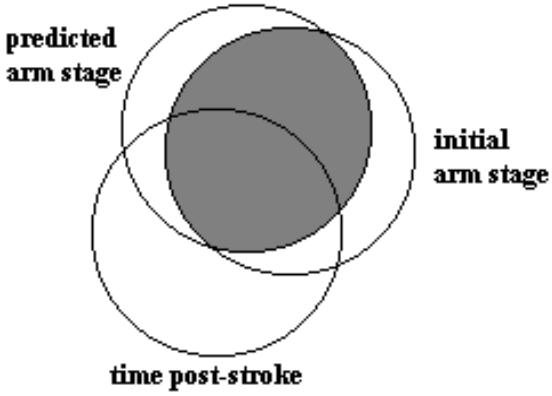
Let us look at another example by taking the information from Scenario 5 where our client has a Stage 2 arm and hand at 4 weeks post-stroke. The independent variables for predicting arm motor recovery are the initial arm stage and time post-stroke.

Predictive Equation for Arm Motor Recovery (R^2 =.80)

0.82 + (1.03 X 2) - (0.03 X 4) = **2.8** [±1.5]

arm stage | weeks

Visually, the predictive equation explains the relationship of both the initial arm motor recovery stage and number of weeks post-stroke with the predicted outcome of arm recovery.



Predictive Equation for Hand Motor Recovery (R2 = .78)

0.53 + (0.98 X 2) = **2.5** [±1.5]

$\overline{\text{hand stage}}$

The initial stage of the hand is the only prognostic indicator.

What do the equations tell us about potential motor recovery? At 4 weeks post-stroke, there is little volitional movement of the arm or hand within the primitive synergistic patterns. As the R^2 is high (80%), there is a strong probability that this client will not achieve functional use of her affected arm and hand. The calculations from the equations for her hemiplegic arm and hand predict only minimal improvement. The upper level of the confidence interval indicates that this woman may achieve a Stage 4 arm and hand at best, moving from the weaker synergy of extension into the stronger flexor synergy. When we look at other clinical factors outlined in the scenario such as her strong neglect and inattention, we can be reasonably certain that the prognosis for improvement is poor. In this way, these predictive equations for the arm and hand enhance clinical decision-making. When the prediction for both arm and hand recovery is poor, there was strong consensus among the panel that the goal for a comfortable, mobile arm and hand was appropriate. If, however, the upper confidence intervals shifts the motor recovery of the arm and hand from a Stage 4 to a Stage 5, then the therapist may feel confident in spending more time on task specific movement training rather than compensatory techniques.

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APPENDIX B

Recommended Outcome Measures for the Post-stroke Arm and Hand

The following outcome measures were selected from the Physical Rehabilitation Outcome Measures[1], the 1996 AHCPR Report[2] and from the recommendations of panel members. The majority of the measures are listed in Physical Rehabilitation Outcome Measures[1]; the chosen measures had to meet three criteria: (i) currently be in use for research and clinical purposes; (ii) have a minimum of two references about their validation; and (iii) have a citation for the outcome measure within the last 5 years. The new edition of Physical Rehabilitation Outcome Measures (to be published shortly) will outline in detail the selection criteria (personal correspondence with Nancy Mayo, Chairman and Theme Leader, Canadian Stroke Network, Montreal, QC).

The Consensus Panel endorses the use of these recommended measures for treatment planning and outcome prediction.

Outcome Measures

Legend	
*	Physical Rehabilitation Outcome Measures
**	Panel recommendation
***	Agency for Health Care Policy and Research

Outcome Measure	Reference Source
Activity Index[3]	*
Action Research Arm Test[4]	*
Box and Block[5]	*
Chedoke-McMaster Stroke Assessment[6]	*
Duncan Stroke Tool Box[7]	**
Fugl-Meyer Assessment of Sensorimotor Recovery After Stroke[8]	*
Frenchay Activities Index[9]	***
Motor Assessment Scale (MAS)[10]	*
Nine-Hole Peg[11]	*
Purdue Peg Board[12]	*
Rivermead Motor Assessment (RMA)[13]	*
Rivermead ADL Assessment[14]	*
Stroke Rehabilitation Assessment of Movement Measure (STREAM)[15]	*
Upper Extremity Performance Evaluation Test for the Elderly (TEMPA)[16]	*
Wolf Arm Function Test[17]	*

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APPENDIX C

CHEDOKE-McMASTER STROKE ASSESSMENT

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Purpose: The Chedoke-McMaster Stroke Assessment (Chedoke Assessment) is a two-part measure designed for use with clients with stroke. (1,2) It consists of a *Physical Impairment Inventory* and an *Activity Inventory*. The purpose of the *Impairment Inventory* is to determine the presence and severity of common physical impairments. This provides guidance for the selection of appropriate interventions and the evaluation of their effectiveness. Also, this inventory is used in outcome prediction within six months of onset of stroke. The principal purpose of the *Activity Inventory* is to measure functional outcome (clinically important change in physical function). It is designed for use in program evaluation and the determination of the effectiveness of therapeutic interventions.

Description: The Chedoke Assessment is a performance-based measure. The *Impairment Inventory* has six *dimensions*, each measured on a 7-point scale. The dimensions include *shoulder pain, postural control, the arm, the hand, the leg and the foot*. The 7-point scale corresponds to seven stages of motor recovery (with the exception of shoulder pain, which has a unique scale based on severity). The *Activity Inventory* is made up of two indices: *gross motor function* and *walking*. The gross motor function index consists of 10 items, the walking index 5 items. The inventory has a maximum total score of 100.

Conceptual/Theoretical Basis of Construct Being Measured: Four conceptual domains provide the theoretical basis for the measure: physical performance following stroke, measurement theory, the World Health Organization (WHO) classification of disease consequences, and client-centered practice. The theoretical basis related to these conceptual domains is described in detail in Chapter 3 of the Development Manual, (2) and in an independent publication. (3)

Groups Tested with This Measure: Subjects from the inpatient stroke unit of Chedoke-McMaster Rehabilitation Centre, a regional tertiary care institution. (1.2.4-6) (ii) Stroke survivors and caregivers in the community. Survivors were discharged from the inpatient or day hospital stroke population 6 to 24 months prior to this study. (7) (iii) Two additional studies examined the suitability of the Chedoke Assessment for use on a population of individuals with Acute Neurological Disorders and Acquired Brain Injury. (8,9)

Languages: The measure and the development manual are available in English only.

Application/Administration: Detailed administration guidelines are contained in the Development Manual. (2)

Testing Time: Approximately 45 to 60 minutes is required to complete the assessment, depending on the client's level of endurance and concentration.

Equipment: foot stool, pillows, stop watch, 2 metre line marked on the floor, floor mat, chair with armrests, pitcher with water, measuring cup, ball 2.5 inches in diameter, adjustable table

Training Needed: Clinical use of the measure over time provides adequate training for most clinicians, however, in a recently completed study it was determined that reliability in administration was improved significantly by attendance at a training workshop. (10)

Typical Reliability Estimates:
Internal consistency: Not applicable.
Inter-Rater and Test-Retest: To evaluate the interrater reliability of the Impairment Inventory, clients were assessed concurrently by both a treating and a research physical therapist during the first week of admission. To estimate intrarater reliability the initial assessment was videotaped, and the treating therapist scored the videotape after a minimum interval of two weeks. To examine the test-retest reliability of the Impairment Inventory, both the treating and research therapists on admission and again within 5 days assessed clients separately. Because the Activity Inventory is designed to assess change in a client's function it was important to assess the amount of variability that a client would demonstrate in a "stable" state. Test-retest reliability was therefore estimated in addition to interrater reliability. Clients were assessed concurrently by both the treating and research therapists on admission and again within 5 days. (1,2)

Typical Validity Estimates:

Content: A study was carried out to test the assumption that the content in the Activity Inventory is representative of skills that are important to clients (clients with stroke and caregivers)(7). Thirty-four clients discharged from inpatient rehabilitation programs and their caregivers were surveyed to determine their judgements of the importance of the items. On a scale where 1 = "not at all important" and 7 = "extremely important," all items received a 7, the highest possible score, from at least one person in each group.

Criterion – Predictive: A study of 182 consecutively admitted clients was carried out. (2,6) A literature review identified the prognostic variables that were the most statistically significant in predicting outcomes. A regression analysis was performed on the outcomes of interest and on the prognostic variables, which were identified from the literature review. The resulting equations for predicting clinical outcomes following rehabilitation are contained in Chapter 8 of the Development Manual. (2) Two previous studies also reported on similar work on a previous version of the measure. (5,6)

Construct Validity-Convergent: The following table shows the relationships established between the Chedoke Assessment and two other measures. The Fugl-Meyer is a measure of impairment and the Functional Independence Measure is a measure of activity. (1,2)

Reliability of the Chedoke Assessment

Inventory	Intrarater ICC	Intrarater 95% CI	Interrater ICC	Interrater 95% CI	Test-retest ICC	Test-retest 95% CI
Impairment						
Shoulder Pain	0.96	0.92-0.98	0.95	0.91-0.98	0.75	0.55-0.87
Postural Control	0.96	0.93-0.98	0.92	0.84-0.96	0.80	0.63-0.90
Arm	0.95	0.89-0.97	0.88	0.76-0.94	0.84	0.72-0.92
Hand	0.93	0.85-0.96	0.93	0.84-0.96	0.85	0.72-0.92
Leg	0.98	0.96-0.99	0.85	0.73-0.93	0.92	0.85-0.96
Foot	0.94	0.87-0.97	0.96	0.91-0.98	0.85	0.71-0.92
Total score	**0.98**	**0.95-0.99**	**0.97**	**0.94-0.98**	**0.94**	**0.89-0.97**
Activity						
Gross motor function						
Walking	-	-	0.98	0.97-0.99	0.96	0.93-0.98
	-	-	0.98	0.95-0.99	0.98	0.96-0.99
	-	-	**0.99**	**0.98-1.00**	**0.98**	**0.95-0.99**
Total score						

Construct and Concurrent Validities of the Chedoke Assessment by comparing it to Fugl-Meyer Measure and Functional Independence Measure (n=32) (1,2)

	Fugl-Meyer Measure					Functional Independence Measure		
Chedoke Assessment	Balance	Shoulder, elbow, forearm, wrist and hand	Hip, knee, foot and ankle	Upper limb joint pain	**TOTAL SCORE**	Mobility subscore	Locomotion subscore	**TOTAL SCORE**
Impairment Inventory								
Postural Control	**0.84**†	0.53	0.65	0.46	0.69	0.74	0.66	0.73
Arm and Hand	0.46	**0.95**‡	0.76	0.49	0.89	0.40	0.46	0.36
Leg and Foot	0.68	0.79	**0.93**‡	0.56	0.87	0.58	0.53	0.58
Shoulder Pain	0.38	0.49	0.59	**0.76**†	0.66	0.40	0.36	0.36
TOTAL SCORE	0.67	0.88	0.90	0.65	**0.95**‡	0.59	0.57	0.57
Activity Inventory								
Gross Motor Function	0.88	0.49	0.67	0.40	0.65	**0.90**‡	0.85	0.81
Walking	0.68	0.40	0.41	0.31	0.49	0.83	**0.85**†	0.64
TOTAL SCORE	0.85	0.46	0.61	0.38	0.62	0.91	0.89	**0.79***

p>0.60 (one-tailed) of numbers on diagonal based on Fisher's Z transformation *p<0.05, †p<0.01, ‡p<0.001)

Construct Validity-/Sensitivity to Change Estimates: There is a correlation (r=0.749) between important change as perceived by clients and change score of the measure. Also, there is a relationship between severity of the disability and the value clients place on change in function, and a correlation (r=0.62) between total score on the Activity Inventory and living arrangements. (7)

Interpretability:

General Population Values: Not Applicable

Typical Responsiveness Estimates: Mean change scores for the Gross Motor Function Index, Walking Index and Activity Inventory were determined. For the Activity Inventory a score of 0 equated with no change, 8 equated to small change, and 20 to large change. Details for subgroups and the importance of the change to individuals and their caregivers are contained in a recent publication. (2,7)

References:

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7. Huijbregts MP, Gowland C, Gruber R. Measuring clinically important change with the Activity Inventory of the Chedoke McMaster Stroke Assessment. Physiotherapy Canada 2000; 52(3): 295-304.
8. Barclay-Goddard R. Physical Function Outcome Measures Suitable for use in Acute Neurology. Synapse 1996; 16(1):2-5.
9. Crowe J, Harmer D, Sharpe D. Reliability of the Chedoke-McMaster Disability Inventory in Acquired Brain Injury. Physiotherapy Canada 1996; 48(2). Abstracts of scientific presentations at the Annual Congress.
10. Miller P, Stratford P, Gowland C, VanHullenaar S, Torresin W. Comparing two methods to train therapists to use the Chedoke-McMaster Stroke Assessment. Proceedings of the 13th International Congress of WCPT, Yokohama, Japan: WCPT 1999.

Chedoke-McMaster Stroke Assessment
SCORE FORM IMPAIRMENT INVENTORY: SHOULDER PAIN AND POSTURAL CONTROL

POSTURAL CONTROL: Start at Stage 4. Starting position is indicated beside the item or underlined. No support is permitted.
Place an X in the box of each task that is accomplished. Score the highest Stage in which the client achieves at least two Xs.

	SHOULDER PAIN		POSTURAL CONTROL	
1	☐	constant, severe arm and shoulder pain with pain pathology in more than just the shoulder	1	☐ not yet Stage 2
2	☐	intermittent, severe arm and shoulder pain with pain pathology in more than just the shoulder	2 Supine Side lying Sit	☐ facilitated log roll to side lying ☐ resistance to trunk rotation ☐ static righting with facilitation
3	☐	constant shoulder pain with pain pathology in just the shoulder	3 Supine Sit Stand	☐ log roll to side lying ☐ move forward and backward ☐ remain upright 5 sec
4	☐	intermittent shoulder pain with pain pathology in just the shoulder	4 Supine Sit Sit	☐ segmental rolling to side lying ☐ static righting ☐ stand
5	☐	shoulder pain is noted during testing, but the functional activities that the client normally performs are not affected by the pain	5 Sit Sit Stand	☐ dynamic righting side to side, feet on floor ☐ stand with equal weight bearing ☐ step forward onto weak foot, transfer weight
6	☐	no shoulder pain, but at least one prognostic indicator is present • Arm Stage 1 or 2 • Scapula malaligned • Loss of range of shoulder movt - flexion/abduction < 90° or external rotation < 60°	6 Sit Stand Stand	☐ dynamic righting backward and sideways with displacement, feet off floor ☐ on weak leg, 5 seconds ☐ sec ☐ sideways braiding 2 m
7	☐	shoulder pain and prognostic indicators are absent	7 Stand Stand Stand	☐ on weak leg: abduction of strong leg ☐ tandem walking 2 m in 5 sec ☐ walk on toes 2 m
	☐	**STAGE OF SHOULDER PAIN**		☐ **STAGE OF POSTURAL CONTROL**

Chedoke-McMaster Stroke Assessment
SCORE FORM: IMPAIRMENT INVENTORY: STAGE OF RECOVERY OF ARM AND HAND

ARM and HAND: Start at Stage 3. Starting position: sitting with forearm in lap in a neutral position, wrist at 0° and fingers slightly flexed. Changes from this position are indicated by underlining. Place an X in the box of each task accomplished. Score the highest Stage in which the client achieves at least two Xs.

	ARM	**HAND**
1	☐ not yet Stage 2	☐ 1 not yet Stage 2
2	☐ resistance to passive shoulder abduction or elbow extension ☐ facilitated elbow extension ☐ facilitated elbow flexion	☐ positive Hoffman ☐ resistance to passive wrist or finger extension ☐ facilitated finger flexion
3	☐ touch opposite knee ☐ touch chin ☐ shoulder shrugging > ½ range	☐ wrist extension > ½ range ☐ finger/wrist flexion > ½ range ☐ <u>supination, thumb in extension</u>: thumb to index finger
4	☐ extension synergy, then flexion synergy ☐ shoulder flexion to 90° ☐ <u>elbow at side, 90° flexion</u>: supination, then pronation	☐ finger extension, then flexion ☐ thumb extension > ½ range, then lateral prehension ☐ finger flexion with lateral prehension
5	☐ flexion synergy, then extension synergy ☐ shoulder abduction to 90° with pronation ☐ <u>shoulder flexion to 90°</u>: pronation then supination	☐ finger flexion, then extension ☐ <u>pronation</u>: finger abduction ☐ <u>hand unsupported:</u> opposition of thumb to little finger
6	☐ hand from knee to forehead 5 x in 5 sec. ☐ <u>shoulder flexion to 90°</u>: trace a figure 8 ☐ <u>arm resting at side of body:</u> raise arm overhead with full supination	☐ <u>pronation</u>: tap index finger 10 x in 5 sec ☐ <u>pistol grip</u>: pull trigger, then return ☐ <u>pronation:</u> wrist and finger extension with finger abduction
7	☐ clap hands overhead, then behind back 3 x in 5 sec ☐ <u>shoulder flexion to 90°</u>: scissor in front 3 x in 5 sec ☐ <u>elbow at side, 90° flexion</u>: resisted shoulder external rotation	☐ thumb to finger tips, then reverse 3 x in 12 sec ☐ bounce a ball 4 times in succession, then catch ☐ pour 250 ml. from 1 litre pitcher, then reverse
	☐ **STAGE OF ARM**	☐ **STAGE OF HAND**

Chedoke-McMaster Stroke Assessment
SCORE FORM IMPAIRMENT INVENTORY: STAGE OF RECOVERY OF LEG AND FOOT

LEG: Start at Stage 4 with the client in crook lying. FOOT: Start at Stage 3 with the client in supine. Test position is beside the item or underlined. If not indicated, the position has not changed. Place an X in the box of each task accomplished. Score the highest stage in which the client achieves at least two Xs. For "standing" test items, light support may be provided but weight bearing through the hand is not allowed. Shoes and socks off.

	LEG		FOOT	
1		☐ not yet Stage 2	1	☐ not yet Stage 2
2	Crook lying	☐ resistance to passive hip or knee flexion ☐ facilitated hip flexion ☐ facilitated extension	2 Crook lying	☐ resistance to passive dorsiflexion ☐ facilitated dorsiflexion or toe exextension ☐ facilitated plantarflexion
3		☐ <u>abduction</u>: adduction to neutral ☐ hip flexion to 90° ☐ full extension	3 Supine Sit	☐ plantarflexion > ½ range ☐ some dorsiflexion ☐ extension of toes
4	Sit	☐ hip flexion to 90° then extension synergy ☐ bridging hip with equal weight-bearing ☐ knee flexion beyond 100°	4	☐ some eversion ☐ inversion ☐ <u>legs crossed</u>: dorsiflexion, then plantarflexion
5	Crook lying Sit Stand	☐ extension synergy, then flexion synergy ☐ raise thigh off bed ☐ hip extension with knee flexion	5 Stand	☐ <u>legs crossed</u>: toe extension with ankle plantarflexion ☐ <u>sitting with knee extended</u>: ankle plantarflexion, then dorsiflexion ☐ <u>heel on floor</u>: eversion
6	Sit Stand	☐ lift foot off floor 5 x in 5 sec. ☐ full range internal rotation ☐ trace a pattern: forward, side, back, return	6	☐ <u>heel on floor</u>: tap foot 5 x in 5 sec ☐ <u>foot off floor:</u> foot circumduction ☐ <u>knee straight, heel off floor</u>: eversion
7	Stand	☐ <u>unsupported</u>: rapid high stepping 10 x in 5 sec ☐ <u>unsupported</u>: trace a pattern quickly; forward, side, back, reverse ☐ <u>on weak leg with support</u>: hop on weak leg	7	☐ heel touching forward, then toe touching behind, repeat 5 x in 10 sec ☐ <u>foot off floor:</u> circumduction quickly, reverse ☐ up on toes, then back on heels 5 x

☐ **STAGE OF LEG** ☐ **STAGE OF FOOT**

CHEDOKE-McMASTER CLINICAL DATA SET CODING FORM

Equations for predicting clinical outcomes following stroke rehabilitation

Outcome Variable	R^2	Equation	CI
Discharge To (Living Setting)	.38	5.97 - (0.06 x _____) - (0.21 x ____) Gross Motor Function Bladder	± 3.5
Length of Stay	.38	22.03 - (1.18 x _____) - (0.05 x _____) - (0.06 x _____) Leg Adult FIM[SM] Age	± 6.9
Adult FIM[SM]	.65	39.23 + (0.73 x ___) Adult FIM[SM]	± 29.6
Disability Inventory	.73	17.45 + (0.88 x _____) + (4.30 x ___) Gross Motor Function Leg	± 23.3
Gross Motor Function	.70	24.94 + (0.76 x _____) - (0.30 x ____) Gross Motor Function Weeks	± 16.1
Walking	.71	(_____ x 0.28) + (_____ x 1.23) - 4.55 Gross Motor Function (Postural Control + Leg)*	± 9.2
Shoulder Pain	.55	2.33 + (0.44 x _____) + (0.28 x ___) Shoulder Pain Arm	± 1.6
Postural Control	.60	2.23 + (0.35 x _____) + (0.3 x ___) Postural Control Leg	± 1.3
Arm	.80	0.82 + (1.03 x ___) - (0.03 x ____) Arm Weeks	± 1.5
Hand	.78	0.53 + (0.98 x ___) Hand	± 1.5
Leg	.69	1.83 + (0.77 x ___) - (0.02 x ____) Leg Weeks	± 1.5
Foot	.73	1.11 + (0.90 x ___) - (0.03 x ____) Foot Weeks	± 1.6

* Sum of Stage of Postural Control and Stage of Leg

Sources of Information: Adult FIM[SM] - Adult FIM[SM] (total), Bladder
UDS[MR][SM] - Weeks (since onset)
Disability Inventory - Gross Motor Function, Walking
Impairment Inventory - Shoulder Pain, Postural Control, Arm, Hand, Leg, Foot

APPENDIX D

Search strategies for treatment interventions for the hemiplegic upper limb

Search Strategy, Librarian 1(a) - CINAHL 1982 - 2001

1 Cerebral Vascular Accident/ (3990)
2 HEMIPLEGIA/ (565)
3 ARM/ (692)
4 HAND/ (711)
5 exp SHOULDER/ (770)
6 3 or 4 or 5 (2021)
7 1 and 2 and 6 (49)
8 limit 7 to (clinical trial or review or systematic review) (9)

Search Strategy, Librarian 1(b) - CINAHL 1982 - 2001

1 Arm/ or Hand/ (1325)
2 upper extremity.mp. [mp=title, cinahl subject heading, abstract, instrumentation] (671)
3 cerebrovascular accident.mp. [mp=title, cinahl subject heading, abstract, instrumentation] (162)
4 Cerebral Vascular Accident/ (3990)
5 stroke.mp. (3728)
6 1 and 3 (6)
7 1 and 4 (97)
8 2 and 4 (59)
9 upper limb.mp. (292)
10 4 and 9 (47)
11 Treatment Outcomes/ (6455)
12 1 and 4 and 11 (11)

Search Strategy, Librarian 2 - CINAHL 1982 - 2001

1 exp Shoulder Pain/ or exp Shoulder/ or exp Shoulder Injuries/ or exp Hemiplegia/ (1846)
2 shoulder-hand syndrome.mp (8)
3 Thalamic Diseases/ or thalamic pain.mp (4)
4 exp Cerebral Vascular Accident/ (3990)
5 1 or 2 or 3 (1854)
6 4 and 5 (293)

Search strategies for treatment interventions for the hemiplegic upper limb

Search Strategy, Librarian 1 - Medline 1966 - June 2001

1 Cerebrovascular Accident/ (2054)
2 exp Arm/ or upper extremity.mp. (65219)
3 hand.mp. or exp HAND/ (136693)
4 exp HEMIPLEGIA/ (6671)
5 exp REHABILITATION/ (74640)
6 exp Cerebral Infarction/ (11706)
7 exp Cerebrovascular Disorders/ (133873)
8 exp SHOULDER/ or SHOULDER PAIN/ or shoulder.mp. (16345)
9 1 or 6 or 7 (133873)
10 exp Treatment Outcome/ (99753)
11 exp ELECTRIC STIMULATION THERAPY/ or exp EXERCISE THERAPY/ or exp OCCUPATIONAL THERAPY/ or exp PHYSICAL THERAPY/ or exp COGNITIVE THERAPY/ (78783)
12 2 or 3 or 8 (176126)
13 4 or 5 (80646)
14 9 and 12 (2686)
15 13 and 14 (379)
16 11 and 15 (89)
17 10 and 15 (23)
18 limit 17 to (adult <19 to 44 years> or middle age <45 to 64 years> or "aged <65 and over>" or "aged, <80 and over>") (19)
19 from 18 keep 1-8,10-11,13-16,19 (15)
20 limit 16 to (English and (adult <19 to 44 years> or middle age <45 to 64 years> or "aged <65 and over>" or "aged, <80 and over>")) (60)
21 20 not 18 (48)

Search Strategy, Librarian 2 - Medline 1966 - June 2001

1 exp Cerebrovascular Accident/
2 exp Shoulder/ or exp Shoulder Impingement Syndrome/ or exp Shoulder Joint/ or exp Shoulder Pain/
3 (“upper limb” or “upper extremity”).mp [mp=title, abstract, registry number word, mesh subject heading]
4 “arm and hand syndrome”.mp or Hand/
5 exp Hemiplegia/
6 exp Cerebral Infarction/
7 1 or 5 or 6
8 2 or 3 or 4
9 7 and 8
10 limit 9 to (human and (adult <19 to 44 years> or middle age <45 to 64 years> or “aged <65 and over>” or “aged <80 and over>”))

APPENDIX E: EVALUATION FORMS

Oxman-Guyatt Index for Assessing the Quality of Systematic Reviews[1]

Index of the scientific quality of research overviews

1. Were the search methods used to find evidence (original research) on the primary questions(s) stated?
   NO PARTIALLY YES

2. Was the search for evidence reasonably comprehensive?
   NO PARTIALLY YES

3. Were the criteria used for deciding which studies to include in the overview reported?
   NO PARTIALLY YES

4. Was the bias in the selection of studies avoided?
   NO PARTIALLY YES

5. Were the criteria used for assessing the validity of the included studies reported?
   NO PARTIALLY YES

6. Was the validity of all the studies referred to in the text assessed using appropriate criteria (either in selecting studies for inclusion of in analysing the studies that are cited)?
   NO PARTIALLY YES

7. Were the methods used to combine the findings of the relevant studies (to reach a conclusion) reported?
   NO PARTIALLY YES

8. Were the findings of the relevant studies combined appropriately, relative to the primary question the overview addresses?
   NO PARTIALLY YES

9. Were the conclusions made by the author(s) supported by the data and/or analysis reported in the overview? NO PARTIALLY YES

10. How would you rate the scientific quality of this overview?
    Extensive Flaws Major Flaws Minor Flaws Minimal Flaws

1 2 3 4 5 6 7

1. Jaded AR (1996), McQuay HJ. Meta-analyses to evaluate analgesic interventions: A systematic qualitative review of their methodology. J Clin Epidemiol 1996; 49: 235- 43.

APPENDIX E

A checklist for the assessment of the methodological quality of both randomized and non-randomized studies of health care intervention[1]

1. *Is the hypothesis/aim/objective of the study clearly described?*

yes	1
no	0

2. *Are the main outcomes to be measured clearly described in the Introduction or Methods section?*
   If the main outcomes are first mentioned in the Results section, the question should be answered no.

yes	1
no	0

3. *Are the characteristics of the patients included in the study clearly described?*
   In cohort studies and trials, inclusion and/or exclusion criteria should be given. In case-control studies, a case-definition and the source for controls should be give.

yes	1
no	0

4. *Are the interventions of interest clearly described?*
   Treatments and placebo (where relevant) that are to be compared should be clearly described.

yes	1
no	0

5. *Are the distributions of principal confounders in each group of subjects to be compared clearly described?*
   A list of principal confounders is provided.

yes	2
partially	1
no	0

6. *Are the main findings of the study clearly described?*
   Simple outcome data (including denominators and numerators) should be reported for all major finding so that the reader can check the major analyses for conclusions. (This question does not cover statistical tests which are considered below).

yes	1
no	0

7. *Does the study provide estimates of the random variability in the data for the main outcomes?*
   In non-normally distributed data the inter-quartile range of results should be reported. In normally distributed data the standard error, standard deviation or confidence intervals should be reported. If the distribution of the data is not described, it must be assumed that the estimates used were appropriate and the question should be answered yes.

yes	1
no	0

8. *Have all important adverse events that may be a consequence of the intervention been reported?*
   This should be answered yes if the study demonstrates that there was a comprehensive attempt to measure adverse events. (A list of possible adverse events is provided).

yes	1
no	0

9. *Have the characteristics of patients lost to follow-up been described?*
   This should be answered yes where there were no losses to follow-up or where losses to follow-up were so small that findings would be unaffected by their inclusion. This should be answered no where a study does not report the number of patients lost to follow-up.

yes	1
no	0

10. *Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?*

yes	1
no	0

External Validity
All the following criteria attempt to address the representativeness of the findings of the study and whether they may be generalized to the population from which the study subjects were derived.

11. *Were the subjects asked to participate in the study representative of the entire population from which they were recruited?*
    The study must identify the source population for patients and describe how the patients were selected. Patients would be representative if they comprised the entire source population, an unselected sample of consecutive patients, or a random sample. Random sampling is only feasible where a list of all member of the relevant population exists. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as unable to determine.

yes	1
no	0
unable to determine	0

12. *Were those subjects who were prepared to participate representative of the entire population from which they were recruited?*
    The proportion of those asked who agreed should be stated. Validation that the sample was representative would include demonstrating that the distribution of the main confounding factors was the same in the study sample and the source population.

yes	1
no	0
unable to determine	0

13. *Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?*
    For the question to be answered yes the study should demonstrate that the intervention was representative of that in use in the source population. The question should be answered no if, for

example, the intervention was undertaken in a specialist center unrepresentative of the hospitals most of the source population would attend.

yes	1
no	0
unable to determine	0

Internal validity - bias

14. *Was an attempt made to blind study subjects to the intervention they have received?*
    For studies where the patients would have no way of knowing which intervention they received, this should be answered yes.

yes	1
no	0
unable to determine	0

15. *Was an attempt made to blind those measuring the main outcomes of the intervention?*

yes	1
no	0
unable to determine	0

16. *If any of the results of the study were based on "data dredging", was this made clear?*
    Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer yes.

yes	1
no	0
unable to determine	0

17. *In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?*
    Where follow-up was the same for all study patients the answer should yes. If different lengths of follow-up were adjusted for by, for example, survival analysis the answer should be yes. Studies where differences in follow-up are ignored should be answered no.

yes	1
no	0
unable to determine	0

18. *Were the statistical tests used to assess the main outcomes appropriate?*

    The statistical techniques used must be appropriate to the data. For example, non-parametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered yes. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered yes.

yes	1
no	0
unable to determine	0

19. *Was compliance with the intervention(s) reliable?*
    Where there was noncompliance with the allocated treatment or where there was contamination of one group, the question should be answered no. For studies where the effect of any misclassification was likely to bias any association to the null, the question should be answered yes.

yes	1
no	0
unable to determine	0

20. *Were the main outcome measures used accurate (valid and reliable)?*
    For studies where the outcome measures are clearly described, the question should be answered yes. For studies which refer to other work or that demonstrate the outcome measures are accurate, the question should be answered as yes.

yes	1
no	0
unable to determine	0

Internal validity - confounding (selection bias)

21. *Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?*
    For example, patients for all comparison groups should be selected from the same hospital. The question should be answered unable to determine for cohort and case-control studies where there is no information concerning the source of patients included in the study.

yes	1
no	0
unable to determine	0

22. *Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?*
    For a study which does not specify the time period over which patients were recruited, the question should be answered as unable to determine.

yes	1
no	0
unable to determine	0

23. *Were study subjects randomized to intervention groups?*
    Studies which state that subjects were randomized should be answered yes except where method of randomization would no ensure random allocation. For example alternate allocation would score no because it is predictable.

yes	1
no	0
unable to determine	0

24. *Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?*

yes	1
no	0
unable to determine	0

25. *Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?*
This question should be answered no for trials if: the main conclusions of the study were based on analyses of treatment rather than intention to treat; the distribution of known confounders in the different treatment groups was not taken into account in the analyses. In nonrandomized studies if the effect of the main confounders was demonstrated but no adjustment was made in the final analyses the question should be answered as no.

yes	1
no	0
unable to determine	0

26. *Were losses of patients to follow-up taken into account?*
If the numbers of patients lost to follow-up are not reported, the question should be answered as unable to determine. If the proportion lost to follow-up was too small to affect the main findings, the question should be answered yes.

yes	1
no	0
unable to determine	0

27. *Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to change is less than 5%?*
Sample sizes have been calculated to detect a difference of x% and y%

	Size of smallest intervention group	
A	<n	0
B	n_1- n_2	1
C	n_3-n_4	2
D	n_5-n_6	3
E	n_7-n_{8-}	4
F	n_{8+}	5

1. Downs, Sara H., Black, Nick.J. Epidemiol Community Health, 1998; 52: 377-384

APPENDIX E

Generic Critical Appraisal Worksheet (I)

(1) Surname of first author

(2) Year of publication

(3a) Write your name here **(3b) Phone #** **(3c) Date**

(4) Source of funding for the study

- industry
- government agency
- charity
- consumer organization
- professional organization
- other
- not clear
- not reported

(5) Study Design

- RCT, parallel
- RCT, crossover
- Non RCT, historical controls
- Non RCT, contemporaneous
- case series (=> 10 patients)
- single subject (with protocol)
- other (specify)

(6) Direction of investigation

- Prospective
- Retrospective
- Not clear
- Not reported

(7) If study incorporates other diagnostic groups, results are reported separately for stroke clients

- yes continue
- no exclude

(8) Design

Was the study described as randomized?

- No go to question 11
- Yes was randomization appropriate?

Yes no not clear not reported

(9) Was allocation to the groups adequately concealed?

yes no not clear not reported

(10) Was the study described as double blind?

yes no not clear not reported

If yes was blinding appropriate?

yes no not clear not reported

(11) If it is a cohort study, how was the study designed?

Internal comparison: a single cohort is defined that contains a sufficient number of exposed and unexposed subjects

External comparison: an exposed cohort is defined and efforts are made to find another cohort that is unexposed but is similar in other respects to the exposed group

Comparison with the general population: an exposed cohort is defined and comparisons are made with the disease incidence in, for example, the total population of a defined geographic region (considered unexposed)

(12) If a cohort study, were all cases included?

yes no unable to determine

(13) Were all the controls obtained from a randomly selected sample>

yes no unable to determine

(14) Was compliance with the intervention(s) assessed?

yes no unable to determine

(15) Number in study groups Group A [ ] Group B ([ ] Group C [ ]

(16) Nature of the blinding

Patients	**Therapy delivery**	**Outcome assessment**
no	no	no
not clear	not clear	not clear
not reported	not reported	not reported
yes	yes	yes

(17) Health care setting where treatment was given

tertiary care (*university/teaching hospital/rehab facility)*

community (*non affiliated hospitals)*

outpatients

not reported

home

long term care

other (*specify)*

Critical Appraisal Worksheet (III)

(18) Number of hospitals participating # is [ ] ○ unclear ○ not reported

(19) Are the eligibility criteria reported? ○ explicit ○ not explicit ○ no

(20)

Similarity of baseline characteristics			
	Statistically significant	Not statistically significant	Not reported
Mean age			
Gender			
Side of stroke			
Type of stroke			
Time post-stroke			
Degree of impairment			
Degree of functional ability			
Cognition			
Other (*specify)*			
Other (*specify)*			

(20). Was there a comprehensive description of withdrawals and dropouts?

○ yes ○ no ○ unable to determine

(21) How many allocated patients were followed to the end of the study?

	80-100%	**60-79%**	**<60%**	**not clear**	**not reported**	**not applicable**
Total						
Group1						
Group 2						
Group 3						
Group4						

(22) Were the main outcome measures specified?

○ yes ○ no ○ unable to determine

(23) Were the main outcome measures

	yes	**no**	**not clear**	**not reported**
valid				
reliable				
reproducible				
responsive				
assessed by blind observer				

(For studies that refer to other work that demonstrates the outcome measures are accurate, the question should be answered yes)

Reporting

(24) Is the hypothesis /aim/objective of the study clearly described?

○ yes ○ no

(25) Are the main interventions to be measured clearly described in the introduction or method section? *(if the main interventions are first mentioned in the result section, the question should be answered no)*

○ yes ○ no

(26). Are the outcomes to be measured clearly described in the introduction or methods section? *(If the outcomes are first mentioned in the results section, the question should be answered no)*

○ yes ○ no

(27) Are the characteristics of the patients included in the study clearly described?

○ yes ○ no

(28) Are the main findings of the study clearly described?

○ yes ○ no

(29) Does the study provide estimates of variability in the data for the outcomes? *(If the standard error, standard deviation or confidence intervals for normally distributed data are reported, or if the inter-quartile range of results for non-normally distributed data is reported, answer yes)*

○ yes ○ no

(30) Has actual probability values been reported (e.g.) .035 rather than <0.05) for the main outcomes except when the probability value is less than 0.001

○ yes ○ no ○ unable to determine

(31). List measures

1.
2.
3.
4.

(32). Were any adverse effects assessed?

○ yes ○ no ○ unable to determine

(33). List adverse effects, if applicable.

1.
2.

(34). Number of patients with adverse effects per group

	AE1	AE2	AE3	AE4
Group1				
Group2				
Group3				
Group4				

(35). Was statistical significance reported?

○ yes ○ no

(36). Was clinical significance reported?

○ yes ○ no

(37). Presence of a Type I error reported?

○ yes ○ no

(38). Presence of a Type IIU error reported?

○ yes ○ no

(39) Is the intervention feasible?

○ yes ○ no ○ unable to determine

(40). Was a power analysis reported for a no difference conclusion?

○ yes ○ no ○ unable to determine

(41). Were possible biases discussed?

○ yes ○ no ○ unable to determine

Additional Comments.

APPENDIX E

Appraisal Instrument for clinical practice guidelines
Dimension 1: Rigour of the development process[1]

INSTRUCTIONS: **Mark a "v " in the category that best describes your response to the question.**

	Yes	No	Not sure	Not applicable
1.Is the agency responsible for the development of the guidelines clearly identified?				
2. Was external funding or other support received for developing the guidelines?				
3. If external funding or support was received, is there evidence that the potential biases in the funding body(ies) were taken into account?				
4. Is there a description of the individuals (e.g. professionals, interest groups including patients) who were involved in the guidelines development group?				
5. If so, did the group contain representatives of all key disciplines?				
6. Is there a description of the sources of information used to select evidence on which the recommendations are based?				
7. If so, are the sources of information adequate?				
8. Is there a description of the method(s) used to interpret and assess the strength of the evidence?				
9. If so, is (are) the method(s) for rating the evidence adequate?				
10. Is there a description of the methods used to formulate the recommendations?				
11. Is so, are the methods satisfactory?				
12. Is there an indication of how the views of interested parties not on the panel were taken into account?				
13. Is there an explicit link between the major recommendations and the levels of supporting evidence?				
14. Were the guidelines independently reviewed prior to publication/release?				
15. If so, is explicit information given about the methods and how comments were addressed?				
16. Were the guidelines piloted?				
17. If so, is explicit information given about the methods used and the results adopted?				
18. Is there a mention of a date for reviewing or updating the guidelines?				
19. Is the body responsible for the reviewing and updating clearly identified?				
20. Overall, have the potential biases of guideline development been adequately dealt with?				

Appraisal Instrument for clinical practice guidelines
Dimension 2: Context and Content [1]

INSTRUCTIONS: **Mark a "v " in the category that best describes your response to the question.**

	Yes	No	Not sure	Not applicable
21.Are the reasons for developing the guidelines clearly stated?				
22. Are the objectives of the guidelines clearly defined?				
23. Is there a satisfactory description of the patients to which the guidelines are meant to apply?				
24. Is there a description of the circumstances (clinical or non-clinical) in which exceptions might be made in using the guidelines?				
25. If there an explicit statement of how the patient's preferences should be taken into account in applying the guidelines?				
26. Do the guidelines describe the condition to be detected, treated, or prevented in unambiguous terms?				
27.Are the different possible options for the management of the condition clearly stated in the guidelines?				
28. Are the recommendations clearly presented?				
29. Is there an adequate description of the health benefits that are likely to be gained from the recommended management?				
30. Is there an adequate description of the potential harm or risks that may occur as a result of the recommended management?				
31. Is there an estimate of the costs or expenditures likely to occur from the recommended management?				
32. Are the recommendations supported by the estimated benefits, harms and costs of the intervention?				

Comments and suggestions

1. Cluzeau FA, Littlejohns P, Grimshaw JM, Feder G & Moran SE. (1999). Development and application of a generic methodology to assess the quality of clinical guidelines, International Journal for Quality in Health Care, 1, 21-28

APPENDIX F

Introduction to the Summary of the Effectiveness Literature on the hemiplegic arm and hand

Characteristics of the clinical trials

Treatment recommendations found within this clinical practice guideline have been based on the best available evidence. In this summary, you will find the characteristics and results of the clinical trials described under the following headings: author; year; study design; methodology; participants; time post stroke (as a mean); interventions; outcomes; comments as to the strengths and weaknesses of the design; and a critical appraisal rating.

Critical appraisal Ratings

Two raters (the author and one of two OT research interns), trained in the application of the Downs and Black's checklist, assessed the quality of the randomized controlled trials and cohort studies. Using Spearman Correlation, the inter-rater reliability (n=3) was statistically significant, r =0.09, 2-tailed, p=0.002 on 8 observations chosen at random. The mean of the two scores was used as the critical appraisal rating for the studies.

Two raters (the author and one of the hospital therapists) assessed the quality of the randomized controlled trials, cohort studies, case series, and single subject design using the "clinician friendly " checklist. Spearman Correlation between the Downs and Black's Checklist and the "clinician friendly" checklist was statistically significant, r =0.65, p<0.001 on 62 observations. Although the two checklists appeared to be evaluating in a similar fashion the quality of the randomized controlled and cohort studies, only the average score of the valid and reliable measure, the Downs and Black's checklist, was used. Comments on the methodology of the 112 studies came from the "clinician friendly" checklist.

The author assessed the systematic reviews using the Oxman-Guyatt Instrument for Assessing the Quality of an Overview (Jadad, 1996).

Formulation of treatment recommendations

Although treatment recommendations were solely based on those studies that had a cohort group, the results of the case series and single subject design studies were included in the summary of the effectiveness literature in order to provide a comprehensive overview of the evidence to date.

Meta-analyses
Under the supervision of Dr. A. Willan, a recognized methodologist and statistician, the author conducted a series of meta-analyses on studies that were combined according to time post stroke and treatment intervention. As the p-values, effect sizes or binary data were not always available, the Z statistic was used as the common denominator.

Since the summary of the evidence was presented to the consensus panel in June 2001, there have been two additional reviews on rehabilitation for the hemiplegic upper limb. One review (Coote and Strokes, 2001) was a descriptive summary. The other review was a meta-analysis by Hiraoka (2001) that lacked criteria for deciding which studies to include in the overview, guidelines for assessing the validity off the included studies, and a bias in article selection (4/7 on the Oxman-Guyatt Index). Hiraoka also concluded that: (1) neurodevelopmental treatment (NDT) obtained similar results as conventional physical therapy in treating the hemiplegic upper limb; and (2) there was a positive treatment effect of conventional therapy versus no treatment for certain clients. However, Hirako's results differed from our conclusions as to the efficacy of EMG-biofeedback for the upper limb. Hiraoko (2001) stated that EMG biofeedback had a large effect on improving upper extremity function in post-stroke patients. Moreland and Thomson (1994), in their meta-analysis (7/7 on the Oxman-Guyatt Index) reported that their results did not conclusively indicate the superiority of a treatment in favour of biofeedback. In this overview, 6 studies were selected for their validity according to 9 methodologic indicators while Hiraoka (2001) selected 4 randomized controlled trials where the effect sizes (d) could be calculated. The meta-analyses had two studies in common (Basmajian, 1982 and Crow, 1989). Hiarako (2001) included a study by Inglis et al., 1984 that appeared to have serious methodological problems in that: (1) active range of movement was used as a critical variable to judge improvement; (2) it was difficult to determine whether improvement came from physical therapy or biofeedback; and (3) the control group as well as the experimental subjects in the second phase of the study.

The results of the randomized controlled trials and cohort studies are typed in bold. The results of the case series and single subject design are not bolded. The results of the meta-analyses are in italics.

Table 1. Characteristics of included studies that examined electromyographic biofeedback treatment for the hemiplegic arm and hand

Study	Moreland and Thomson, 1994
Design	Systematic review on the efficacy of electromyographic biofeedback compared with conventional physical therapy for improving upper limb function. Treatment studies: Crow (1989): Basmajian (1987); Prevo (1982); Basmajian (1982); Hurd (1980); Smith (1979).
Methods	Studies were evaluated on 9 methodological criteria included a comprehensive search, search criteria, selection bias, studies' internal validity, power, odds-ratios
Participants	CVA; mean age 60.1 years; inclusion criteria included those with sensory loss but excluded those subjects with receptive aphasia
Time post stroke (mean)	Range of 2-416 weeks
Interventions	Crow: EMG biofeedback vs. conventional therapy Basmajian: EMG biofeedback + cognitive behavioural approach vs. NDT Prevo: EMG biofeedback vs. NDT and functional training Basmajian: EMG biofeedback vs. NDT Hurd: EMG biofeedback vs. conventional therapy Smith: EMG biofeedback vs. Bobath and Brunnstrum techniques
Outcomes	Crow: Action Research Arm Test (ARAT), Brunnstrum Fugl-Myer Basmajian: Upper Extremity Function Test (UEFT), Finger Tap Prevo: Brunnstrum FM patterns, muscle force, electromyography, Jebsen Tests Basmajian: UEFT, pinch force, grip force Hurd: EMG, range of motion Smith: Brunnstrum Fugl-Myer stages, muscle tone, function, coordination
Notes	Overall scientific quality excellent. Search methods were clearly identified and reproducible. Intra-observer reliability given. Clear inclusion/exclusion criteria. Odds ratios calculated. Multiple meta-analyses, each tested for homogeneity; potential biases discussed; mathematical conclusion drawn.
Critical appraisal rating	7/7 Oxman-Guyatt Index

Table 1a. Standardized odds ratio scores of function and impairment outcomes (continued)

First author	Odds ratios for functional outcomes	P	Impairments	Odds Ratio for impairments	p
Crow (n=40)	1.89 (0.31 -12.33) 3.50 (0.79-16.26)	.05 .09			
Basmajian (n=29)	4.66 (0.19-999.99)	.62	finger oscillation test	0.53 (0.08-3.38)	.64
Prevo (n=18)	1.00 (0.09-10.67)	.27	elbow flexion force	2.67 (0.13-97.19))	.37
Basmajian (n=37)	2.13 (0.27-20.95)	.36	grip strength pinch strength	1.79 (0.29-11.90) 2.92 (0.51 -18.44)	.40
Smith (n=11)	1.25 (0.02-69.48)	.21			

Table 1b. Main clinical findings of the therapeutic studies (continued)

First author	Outcome
Crow, 1989	no significant differences between the groups before treatment and at follow-up, but at the end of treatment, the EMG biofeedback group scored significantly higher on the tests of arm function
Basmajian, 1987	no significant differences between the two groups
Prevo, 1982	intensive EMG biofeedback therapy had no specific effect on proximal and distal agonists of the hemiplegic arm when compared with conventional physical therapy of a long duration
Basmajian, 1982	no significant differences between the two groups; EMG biofeedback appeared to be effective when upper limb involvement was not severe in a late case or when treatment was started within 3 months post stroke in a severe case
Hurd, 1980	no differences between the groups
Smith, 1979	biofeedback group had a greater degree of control over upper limb movement patterns

Summary of the evidence

Based on their systematic review, Moreland & Thomson (1994) concluded that none of their meta-analyses were statistically significant. The common odds ratio for functional outcomes which included the Action Research Arm Test and Brunnstrum staging was 2.16 (0.82 -5.79), p =0.12. Grip strength, elbow flexion force, and finger oscillation formed the impairment outcomes; the common odds ratio was 1.29 (range 0.43-3.99), p=0.46. These results showed that biofeedback treatment for the hemiplegic upper limb was not more superior to other forms of therapy.

Table 2. Characteristics of included studies that examined electromyographic biofeedback treatment for the hemiplegic arm and hand

Study	Ince et al., 1985	Ince et al., 1987
Design	Critical review of clinical applications of EMG biofeedback	Critical review of clinical applications of EMG biofeedback
Methods	annotative report with no systematic review on 6 studies; inclusion criteria missing; search strategies not given; validity of studies not analyzed; no statistical conclusion or analysis	annotative report with no systematic review; on 9 studies; inclusion criteria missing; search strategies not given; validity of studies partially analyzed; no statistical conclusion or analysis but a partial conclusion was supported by data
Participants	Reporting studies had a majority of mixed diagnoses including spinal cord lesions, torticollis, peripheral nerve injuries, hemiplegia from acquired brain injuries and stroke	Total of 153 CVA; 6 peripheral injuries
Time post stroke (mean)	not reported	from 6 weeks - 10 years
Interventions	biofeedback techniques to reduce muscle spasticity, increase muscle activity and range of motion, eliminate unwanted muscle activity, and to examine the relationship between biofeedback and physical therapy	biofeedback techniques to reduce muscle spasticity, increase muscle activity and range of motion, eliminate unwanted muscle activity, and to examine the relationship between biofeedback and physical therapy
Outcomes	Descriptive analysis with reports of case studies. No conclusion drawn.	Majority of studies did not demonstrate that EMG feedback made a statistical difference.
Notes	Extensive flaws. Author commented on the limited number of studies, the absence of appropriate control measures, and the importance of long-term follow-up.	Major flaws. Author commented on the limited number of studies, the absence of appropriate control measures, paucity of data, small sample sizes, the importance of long-term follow-up, and better study designs
Critical appraisal rating	1/7 Oxman -Guyatt Index	2/7 Oxman-Guyatt Index

Summary of the evidence

Ince (1987) concluded that EMG-biofeedback played an important role in increasing upper limb muscle activity. EMG-biofeedback may improve range of movement but is not superior to traditional physical therapy. EMG- biofeedback did not increase muscle strength in stroke patients but was effective when combined with a general physical therapy program. EMG- biofeedback can decrease reciprocal activity of antagonist muscles.

Table 3. Characteristics of included studies examining the use biofeedback techniques in stroke survivors

Study	Mathieu and Sullivan, 1995	Wolf et al., 1994	Wolf and Binder-Maclead, 1983
Design	Case series (n= 11)	Cohort Control (n =8) Treatment (n= 8)	Cohort Control (n=9) Treatment (n=22)
Methods	Outcome measures blinded.	Random assignment. Concealment not clear. Outcome measures not blinded. Attempt to blind subjects.	No random assignment. Outcomes were blinded
Participants	CVA, n=11; mean age 46.2 yrs; inpatients; had mean pre-testing Brunnstrum stages of 2.9 (1.4).	CVA, n=16; mean age 62.9 yrs; Brunnstrum staging 3-4; absence of receptive aphasia, visual and proprioceptive deficits in elbow; had at least 60° of shoulder flexion and abduction	CVA, n= 31, mean age 55.5 years; outpatients; no evidence of receptive aphasia
Time post stroke (mean)	**3.2 months**	**49.05 months**	**2.2 years**
Interventions	Effect of biofeedback training on shoulder function. Received traditional multi-disciplinary rehabilitation + 12 training sessions of 2 blocks of 5 trials on both sides for 2-3 times a week for 4-8 weeks.	Effect of biofeedback training on weak triceps brachii muscles with hyperactivity present in the opposing biceps brachii vs. sham treatment. Both groups participated in 5 baseline and 10 training sessions. Treatment group received biofeedback training. Control group performed same activities as treatment group with electrodes on and monitor off.	Effect of EMG biofeedback on upper limb functional movements. Treatment group had 60 EMG sessions divided into blocks of 20 for 2-3 sessions a week for 6 months. Control group received no treatment.
Outcomes	Differences measured by Brunnstrum stages; mean torque curves; EMG activity, Fugl-Myer Arm score	Differences measured in active and passive range of movement of elbow; EMG activity; movement speed for each task.	Differences measured by peak EMG activity during isotonic movement; active and passive movement of upper limb; functional tasks; time to return a passively stretched muscle to a pre-strengthened EMG level.
Notes	Small sample size; no follow-up; no control group; missing some post-treatment data	Small sample size; limited training sessions; no follow-up; data missing as to lesion site; power low	Higher triceps, finger and thumb EMG activity in treatment group at baseline; no follow-up; ad hoc sub-analysis; functional tasks lacked meaning and were quasi-impairment
Critical appraisal rating	N/A	16/27	11/27

Summary of the evidence

Wolf et al. (1994) reported that both feedback and non-feedback training procedures were effective in improving elbow extension but did not produce significantly different results. These authors concluded that their initial data demonstrated that stroke survivors might be trained to increase movement without first being trained to specifically inhibit hyperactivity in muscles.

Wolf and Binder-Macleod (1983) reported that the treatment group had decreased peak EMG triceps levels during isotonic contraction (p=0.05), reduced mean EMG triceps resting level (p=0.03), and could relax triceps more quickly (p=0.02). The treatment group showed an increase in mean peak EMG biceps activity (p=0.05). After a quick stretch, the treatment group relaxed not only their forearm muscles more quickly (p=0.004) but also their fingers into extension (p=0.01). Functionally, only one task (tracing a circle drawn on table) was significant (p= 0.03). Subjects who achieved the most improvement in manipulative activities had more volitional finger extension and greater shoulder range of movement initially.

Skelly and Kenedi (1982) reported no statistical difference. Greenberg (1980) reported no differences between the two groups (p =0.58).

Mathieu and Sullivan (1995) reported that 6 out of 11 subjects improved their muscle activity through training but the effect was not enough to reach statistical significance. The 6 successful subjects were found to score >13 on the Fugl-Myer.

Table 3. Characteristics of included studies examining the use biofeedback techniques in stroke survivors (continued)

Study	Skelly and Kenedi, 1982	Greenberg, 1980
Design	Cohort Control (n=9) Treatment (n= 11)	RCT Control (n =10) Treatment (n= 10)
Methods	No random assignment. Outcome measures not blinded.	Random assignment. Concealment not clear. Outcome measures not blinded.
Participants	CVA, n=20; mean age 67.2 yrs; outpatients; full passive range of shoulder movement; no receptive aphasia	CVA, n=20; mean age 64.8 yrs; outpatients; minimum discrepancy of 20° degrees between active and passive elbow extension
Time post stroke (mean)	**1.6 years**	**2.3 years**
Interventions	Effect of biofeedback training in the rehabilitation of patients with sensory loss. Treatment group received biofeedback training for 45 minutes for 3 times a week for 4 weeks + PT techniques to reeducate shoulder movement. Unclear as to what control group received.	Effect of kinesthetic biofeedback training vs. conventional OT on upper limb function. Treatment group received audiovisual kinesthetic biofeedback training with active elbow extension for 1/2 hour twice a week X 4 wks. Control group had regular OT based for same time period.
Outcomes	Differences measured by functional assessment	Differences measured in active and passive range of movement of elbow with goniometer (3 trials)
Notes	Small sample size; no follow-up; methodology unclear; measures not reliable and valid; exercise was a confounder	Small sample size; no follow-up; subject characteristics matched
Critical appraisal rating	4/27	6/27

Table 1. Characteristics of included studies that examine additional therapy for the hemiplegic arm and hand versus traditional treatment in stroke survivors

Study	Kwakkel et al., 1999	Lincoln et al., 1999	Sunderland et al., 1992	Sunderland et al., 1994
Design	RCT Control (n =33) Leg training (n=31) Arm training (n=33)	RCT Control (n =95) Treatment by qualified PT (n= 94) Treatment by PTA (n=93)	RCT Control (n=65) Treatment (n=67)	RCT Control (n=48) Treatment (n=47)
Methods	Random assignment & concealment appropriate. Outcome measures and subjects were blinded.	Random assignment & concealment appropriate. Outcome measures blinded.	Random assignment appropriate. Concealment unclear. Outcome measures not blinded. Stratified.	Random assignment appropriate. Concealment unclear. Outcome measures not blinded. 73% follow-up at 1 yr.
Participants	CVA, n=97; mean age 65.8 yrs; inpatients; 18 centers; only MCA infarcts that were confirmed by CT	CVA, n=282; median age 73 yrs; one center; inpatients	CVA; n= 132; mean age 67.4 yrs.; 1 center; inpatients and followed as outpatients	CVA; n=97; mean age 67.4 yrs.; 1 center; inpatients and then followed as outpatients
Time post stroke (mean)	7.2 days	12 days (median)	8.75 days	8.75 days
Interventions	Effect of rehabilitation program with emphasis on arm training vs. program with emphasis on leg training vs. control with arm and leg immobilized in air splint for 30 minutes a day, 5 days a week, for the first 20 weeks after stroke. As well, all 3 groups received 15 minutes of leg and arm training a day and 1.5 hours per week of ADL training by an OT.	Effect of routine (control) physiotherapy vs. additional therapy by qualified PT or PTA. Routine PT (Bobath) for 30-45 minutes a day for 5 days a week for 5 weeks. Qualified PT was regular program + extra 2 hours a week by qualified PT for 5 weeks (total 10 hours); PTA treatment was regular program + extra 2 hours of supervised activities for 5 weeks (total 10 hours).	Effect of enhanced therapy vs. traditional therapy. Traditional therapy consisted of mainly Bobath techniques for 10 weeks. Enhanced therapy consisted of Bobath exercises, EMG biofeedback, microcomputer games and goal setting for 18 weeks. Intensity greater for enhanced group.	Effect of enhanced therapy vs. traditional therapy. Traditional therapy consisted of mainly Bobath techniques for 10 weeks Enhanced therapy consisted of Bobath exercises, EMG biofeedback, microcomputer games and goal setting for 18 weeks. Intensity greater for enhanced group.
Outcomes	Differences measured by Barthel Index, Action Research Arm Test, functional ambulation, Frenchay Activities Index.	Differences measured by Rivermead Assessment, Action Research Arm Test, 10 hole Peg Test, grip dynameter, modified Ashworth,	Differences measured by Extended Motricity Index, Frenchay Arm Test, 9 Hole Peg Test, Barthel ADL	Differences measured by Extended Motricity Index, Frenchay Arm Test, 9 Hole Peg Test, Barthel ADL
Notes	7.7% drop-out; follow-up every 2 weeks for 26 weeks; group characteristics matched; 10 subjects learned about allocation	50% of subjects in extra PT / PTA groups did not complete 10 hours of additional treatment; not enough contrast between groups; follow-up at 3, 6 months	Follow-up at 6 months, 1 yr. Group characteristics matched. 47% in enhanced group developed pain vs. 26% in the traditional group	29%of clients in traditional group reported pain vs. 33% in the enhanced group
Critical appraisal rating	18/27	26/27	21/27	21/27

Table 1. Characteristics of included studies that examine additional therapy for the hemiplegic arm and hand versus traditional treatment in stroke survivors (continued)

Study	Van der Lee et al., 2001
Design	Systematic review of randomized control trials of exercise therapy for arm function in stroke patients. Treatment studies: Kwakkel (1999); Feys (1998); Van der Lee (1999); Lincoln 1999); Duncan (1998); Jongbloed (1989); Sunderland (1992,94); Taub (1993); Werner (1996); Volpe (2000); Gelber (1995); Altshuler (1999); Logigian (1983).
Methods	Studies evaluated on 19 methodological criteria including a comprehensive search, study criteria, selection bias, studies' internal validity
Participants	CVA who participated in studies that examined exercise therapy aimed at improving motor function of the hemiplegic arm. Studies concerning pharmacological interventions, biofeedback techniques, or electrical stimulation were excluded.
Time post stroke (mean)	384 days
Interventions	Kwakkel: extra 1/2 hour arm training vs. immobilization of arm in air splint Feys: rocking chair, air splint (sensorimotor stimulation +usual rehab vs. rocking chair + fake short-wave therapy + usual rehab Van der Lee: forced use + intensive arm training vs. intensive bimanual arm training Lincoln: additional 2 hours/ week arm training from senior research PT or PTA vs. daily routine PT only Duncan: home-based exercise program vs. usual care Jongbloed: sensorimotor integrative movement vs. functional treatment Sunderland: enhanced therapy vs. conventional therapy Taub: forced use vs. procedures to focus attention on involved upper limb Werner: 2 hours of OT and PT vs. no treatment Volpe: sensorimotor exercises by robotic device+ standard therapy vs. exposure to robotic device+ standard therapy Gelber: NDT vs. traditional functional retraining Altschuler: symmetric movements using a mirror vs. symmetric movements using a plastic sheet Logigian: facilitation techniques vs. traditional techniques
Outcomes	various outcome measures of impairment and function of the upper limb
Notes	No mathematical analysis of the data; no meta-analysis or effect sizes calculated; findings were not combined to reach a conclusion so reader is left to re-evaluate individual studies. Major flaws of review as measured by the Oxman-Guyatt Index for Assessing the Quality of Systemic Reviews
Critical appraisal rating	Oxman- Guyatt 3 /7

Summary of the evidence

In contrast to Van der Lee's grouping of the randomized controlled trials, the studies were divided into similar groupings by time post stroke, purpose of the study, and the type of exercise that was being evaluated. Some of the studies will be found under different headings within this section.

At week 20, Kwakkel et al. (1999) reported that the leg-training group had higher scores than the control group for ADL ability (p <0.05), walking (p < 0. 05), and upper limb dexterity (p < 0.001) .The arm-training group only differed significantly from the control group in dexterity (p < 0.01). There was no significant differences at 20 weeks between the arm-training and leg-training groups on the Frenchay Activities Index, Z =1.15, p < 1.96. At 26 weeks, there was a significant difference between the groups only on the Action Research Arm Test (ARAT); median and range scores were 0 (0-2.5) for the control group, 4 (0-38) for the arm-training group, and 3 (0-56) for the leg-training group. There was not a significant difference in performance on the ARAT between the arm-training and leg-training group, Z =0.48, p < 1.96.

Lincoln et al, (1999) reported that there was no significant difference between the groups on any of the measures. In terms of upper limb impairment, only 34% scored > 1 on the Rivermead arm scale, only 10% had sufficient dexterity to perform the Ten Hole Peg Test, and only 20% scored>9 on the ARAT. In comparing additional treatment by a qualified physiotherapist to routine physiotherapy on the Rivermead Assessment post-treatment, there was an Odds Ratio of 0.61, giving a Z score of 1.07, p < 1.96. Additional articles cited in the literature by Parry (1999) and Parry, Lincoln and Appleyard (1998) reported an ad-hoc analysis of a subset of subjects in the same study as reported by Lincoln et al. (1999). *Considerable limitations to this sub-analysis from the original data make the findings speculative and are not reported.*

Sunderland et al. (1992) reported that on the Extended Motricity Index there was a therapy x time interaction in favour of enhanced therapy, p =0.006 and this interaction did not differ between the mild and severe sub groups within the first month. There was no significant difference between the two groups in the time period between one and six months, p=. 2, Z= .317, p < 1.96. At 6 months, there was a small but statistically significant increase in strength, speed and range of movement in those subjects with mild impairments within the enhanced group.

Sunderland et al. (1994), in a one-year follow-up study, reported that the slight advantage seen at 6 months on the Extended Motricity was non-significant by one year. Furthermore, there was no significant difference between the two groups on the Frenchay Arm Test or the Nine Hole Peg Test.

Summary of meta-analyses

Combing the Z scores from three of the studies [Kwakkel (1999), Lincoln (1999) and Sunderland (1992)], it would appear that there was no significant benefit of intensive training for the hemiplegic upper limb over routine or conventional therapy at 6 months, Z= 1.56, p < 1.96.

Table 2. Characteristics of included studies that examine different exercise techniques in stroke survivors

Study	Hummelsheim et al., 1997	Hanlon, 1996	Trombly et al., 1986	Trombly et al., 1983
Design	Cohort Control (n=10) Treatment (n=30)	RCT Control (n=6) Random practice (n=9) Blocked practice (n=9)	Cohort control (n=5) Resisted extension (n=5) Resisted grasp (n=5) Ballistic (n=5)	Case series (n=10)
Methods	Outcome measures not blinded. Treatment group stratified into severe, moderate and mild impairment groups	Random assignment appropriate. Outcome measures not blinded.	Outcome measures not blinded; no random assignment	Order effect balanced by random assignment to one of 4 groups. Outcome measures not blinded
Participants	CVA, n=40; mean age 59.4 yrs; CT -confirmed ischaemic lesions in MCA	CVA, n= 24; mean age 50.1 yrs; 2 centers; outpatients; minimum score of 30 on Fugl-Myer Arm	CVA; n= 20; mean age 66.8 yrs.; 1 center; inpatients; Brunnstrum hand stage 3-5	CVA; n= 10; mean age 63.1 yrs.; 1 center; paid volunteer outpatients; Brunnstrum hand stage 3-5
Time post stroke (mean)	**99 days**	**33.9 months**	**6.4 weeks**	**14 months**
Interventions	Effect of 5 physiotherapy facilitatory techniques applied randomly to extensor Carpi radialis . Single transcranial magnetic stimuli applied before & during :cutaneous stimuli (tapping); taking weight through elbow; proximal preinnervation task; maximum isometric contraction of unaffected wrist & finger extensors; active wrist and finger extension . Control group consisted of healthy normals	Effect of random practice vs blocked practice on rate of acquisition and retention of a functional movement sequence. Random practice group had 10 practice trials per day on procedure alternated with 3 tasks of pointing, touching objects and spots in different planes with a 60 second rest. Blocked practice group had 10 practice trials in 2 blocks of 5 per day with 60-second rest; control group had no practice.	Effect of 3 types of exercise on ability to extend fingers. Unresisted extension/flexion of hand followed by 3 repetitions of each type of exercise with unresisted extension/flexion of hand repeated. Exercises were resisted extension vs rubber band , rapid and slow unresisted extension to flick ping pongs, maximal resisted grasp of cylinder for 20 sessions (time not specified)	Effect of 5 types of exercise on ability to extend fingers. Unresisted extension/flexion of hand followed by 3 repetitions of each type of exercise with unresisted extension/flexion of hand repeated. Exercises were resisted extension vs rubber band, rapid and slow unresisted extension to flick ping-pongs, maximal resisted grasp of cylinder, grasp and release of lightweight cylinder.
Outcomes	Differences measured by EMG activity of paretic extensor carpi radialis	Differences measured by performance of experimental task that approximated opening cupboard door, getting coffee cup, etc.	Differences measured by range of movement, Halstead oscillation test, pick up and release objects	Differences measured by range of movement and EMG activity
Notes	Small sample size; functional value needs to be investigated	Small sample size; random practice group younger and less months post stroke	Small sample size; resisted & ballistic groups had higher levels of motor recovery	Small sample size; high inter-subject variability; no controls. Questionable reliability
Critical appraisal rating	10/27	9/27	14/27	N/A

Summary of the evidence

Hummelsheim et al. (1997) reported that all five techniques enhanced the frequency and amplitude of the muscular response potentials while diminishing the response latencies. However, the most prominent effects were seen when the subjects (treatment and control groups) were asked to voluntarily extend their wrists ($p < 0.005$). No significant difference was found among the other facilitation techniques in all subjects. Only the cutaneous/proprioceptive technique exerted a facilitatory effect on the group with the most severe impairments ($p < 0.008$).

Hanlon (1996) found that was a significant difference between the two groups on both retention tasks, with random practice more effective than blocked practice, $p<0.01$ and $p= 0.05$ respectively. Hanlon concluded that therapy that intersperses activities may be more effective in improving upper limb function than continuous repetitive training.

Trombly et al. (1986) concluded that no one exercise improved all three components of function significantly more than another.

Trombly (1983) reported that slow, unresisted extension exercise preferentially recruited extensor digitorum, $p < 0.001$. No one exercise caused significant immediate changes in range of motion, flexor/extensor balance, time required to open the hand, or in the activity level of the extensor digitorum during the task of opening of the hand.

Table 3. Characteristics of included studies that examine home-based exercise therapy versus no treatment for the hemiplegic arm and hand

Study	Duncan et al., 1998	Gursel et al., 1998	Holmqvist et al., 1998	Turton and Fraser, 1990
Design	RCT Control (n =10) Experimental (n=10)	Cohort Control (n =22) Treatment (n= 21)	RCT Control (n=40) Treatment (n- 41)	Cohort Control (n =10) Home exercises (n= 12)
Methods	Random assignment & concealment appropriate. Outcome measures and subjects were blinded.	No random assignment Outcome measures not blinded. Prospective design	Random assignment & concealment appropriate. Outcome measures and subjects were blinded.	No random assignment. Outcome measures and subjects were not blinded.
Participants	CVA, n=20; mean age 67 yrs.; 12 centres; outpatients; had mild to moderate impairments	CVA, n=43; mean age 61 yrs.; one center; control group received no treatment because of socio-economic reasons or lack of rehabilitation beds	CVA; n= 81; mean age 71.7 yrs.; 1 centre; cognitive ability > 23 on Mini-Mental;	CVA, n=22; mean age 58.5 yrs.; outpatients; subjects with sensory, proprioceptive and motor deficits included
Time post stroke (mean)	**61 days**	**21 days approximately**	**with 5-7 days (not specified)**	**20 weeks**
Interventions	Effect of home exercise program vs. routine care. Home group had individual exercises (PNF + theraband) with 23 visits of 90 minutes 3 times a week for 8 weeks + additional home exercises for 4 weeks. Routine care group received care with a total of 39 visits to OT/PT of 44 minutes in duration	Effect of routine rehabilitation vs. no treatment. No description of therapy, and nothing specific to the upper limb.	Effect of rehabilitation at home after early supported discharge from hospital vs. routine care. Home treatment consisted on individually designed task and context -orientated exercises + education and counseling. Control group received routine rehabilitation.	Effect of rehabilitation at home after discharge from hospital vs. no treatment. Home group had individual designed exercises taught to subject and caregiver by PT who upgraded them at following visits. Control group had assessment only. Followed for minimum of 8 weeks.
Outcomes	Differences measured by Barthel Index, Fugl-Myer Arm, MOS-36; Lawton Instrumental Activities of Daily Living	Differences measured by Brunnstrum, Upper Extremity Function Test, Ashword-Peterson Scale for muscle tone; Barthel; Lowenstein Index	Differences measured by Barthel, 9 Hole Peg Test, Katz Index; Sickness Impact Profile; Frenchay; Lindmark motor Capacity Assessment	Differences measured by Southern's Motor Group Assessment, 10 Hole Peg Test
Notes	Small sample size; no follow-up; group characteristics matched; confounder of natural recovery; lesion sites not confirmed by CTs	53% and 59% drop-out in the control and treatment groups respectively; follow-up at 6 months; group characteristics matched	Intensity of therapy not described; follow-up at 3 months; control group had more right CVAs	Small sample size; no follow-up; control group had higher Peg Test scores, fewer caregivers, and shorter time from onset of stroke to study
Critical appraisal rating	22/27	12/27	18/27	11/27

Summary of the evidence

Duncan et al. (1998) reported that there was no statistical difference between the two groups in regards to improvement in upper limb arm impairment and function on any of the appropriate measures, p >0.2, Z=0.317, p< 1.96.

Gursel et al. (1998) reported that both groups improved significantly (p=0.0002) in motor impairment and performance on the UEFT (p=0.0004). At six months, the untreated (control) group showed significant improvement in impairment over the group receiving rehabilitation, p =0.022, Z =2.20, p>1.96. Although there was not significant differences between the initial Brunnstrum staging of the subjects, the untreated group had a clinically significant higher mean {2.68 (1.19) vs. 2.14 (1.19)} initially which was maintained at the end of the study {4.40 (1.65) vs. 3.47(1.07)}. There was no difference on functional performance as measured by the UEFT, p=0.947, Z=0.04, p <1.96.

Turton and Fraser (1990) reported a statistical difference in favour of the treatment group on the 10 Hole Peg Test, p<0.05, Z=2.43, p>1.96. There was no difference between the two groups on the Southern's Motor Assessment, p >0.05.
The authors reported that most patients did not want home therapy to replace outpatient treatment.

Holmqvist et al. (1998) reported that there were no differences between the two groups on the Peg Test, p = 0.73, Z =1.10, Lindmark Motor Capacity Assessment, p =. 3214, Z = .464, or on the Frenchay, p = 0.5351, Z = .790.

Summary of the meta-analyses

Combining the available Z scores from three of the studies [Duncan (1998), Holmqvist (1998) and Turton (1990]), there was a small significant effect in favour of home exercises over no treatment, Z = 2.22, p >1.96.

Table 4. Characteristics of included studies that examine NDT versus other types of therapies in stroke survivors

Study	Gelber et al., 1995	Lord et al., 1986	Wagenaar et al., 1990	Vanderlee et al., 1999
Design	RCT NDT (n =15) TFR (n= 12)	Cohort NDT (n =20) TFR (n=19)	Single subject design (n= 7)	RCT Control (n =31) Treatment (n= 31)
Methods	Randomization and concealment not clear. Outcome measures not blinded.	No random assignment. Outcome measures not blinded. Retrospective study.	Outcome measures not blinded; random assignment of condition. BCBC design	Problems with randomization Concealment appropriate. Outcome measures blinded.
Participants	CVA, n=27; mean age 71.8 yrs; 1 center; inpatients; patients with hemorrhages excluded	CVA, n= 39; mean age not described; 2 centers; shorter length of stay in hospital for TFR group	CVA; n= 7; mean age 40-80 yrs.; 1 center; inpatients; MCA infarcts confirmed by CT	CVA, n=62; mean age 61 yrs; 5 centers; outpatients; had min. of. 20°of active wrist extension & 10°finger extension
Time post stroke (mean)	**12.5 days**	**17.6 days**	**acute -5-9 days**	**3.0 years**
Interventions	Effect of traditional functional training (TFR) vs. neurodevelopmental techniques (NDT). Treatments continued until discharge from inpatient or outpatient program. Daily amount of time not specified.	Effect of traditional functional training (TFR) vs. neurodevelopmental techniques (NDT). TRF had 30 minutes sessions twice a day with focus on multiple repetitions of specific activities with functional and sensory retraining. NDT group had 45 minutes -1 hr sessions twice a day with facilitation of upper limb movement	Effect of traditional functional training (TFR) vs. neurodevelopmental techniques (NDT). Treatment phase alternated , 5 weeks in each treatment phase with each session for 30 minutes for a period of 21 weeks.	Effect of forced use therapy vs. NDT. Unaffected arm immobilized with sling + mitt for 12 days, 90% of the day. Control group received bimanual activities, posture exercises, and decrease of abnormal tone (NDT) for 5 days/week for 6 hours for 2 weeks. Group activities, attention, exercises equally divided between the 2 groups.
Outcomes	Differences measured by Box and Block; Nine Hole Peg Test	Differences measured by telephone questionnaire.	Differences measured by Action Research Arm Test	Differences measured in ARAT, Fugl-Myer (arm); Motor Activity Log
Notes	Small sample size; follow-up at 6 and 12 months; included only pure motor ischemic strokes; questionable sensitivity of measures	Small sample size; Subjects in NDT group were later beginning rehabilitation; validity /reliability of telephone questionnaire	Small sample size; carry-over effect with no wash-out period; confounder of natural recovery	Differences in subject characteristics with treatment group starting with higher scores in all measures.
Critical appraisal rating	15/27	5/27	N/A	21/27

Table 4. Characteristics of included studies that examine NDT versus other types of therapies (continued)

Study	Dickstein et al., 1986	Basmajian et al., 1987	Logigan et al., 1983
Design	RCT Traditional (n=57) NDT (n= 38) PNF (n=36)	RCT NDT (n =16) Biofeedback (n=13)	RCT Traditional (n=21) NDT (n=21)
Methods	Randomization and concealment not clear. Outcome measures not blinded.	Randomization with stratification and balancing across strata appropriate. Concealment not clear. Outcome measures blinded.	Outcome measures not blinded; random assignment and concealment not clear
Participants	CVA, n=131; mean age 70.5 yrs; 1 center; inpatients	CVA, n -29; mean age 62 yrs.; 1 center; outpatient volunteers; some ability to extend wrist and fingers	CVA; n=42; mean age 61.6 yrs.; 1 center; inpatients
Time post stroke (mean)	**16 days**	**16 weeks**	**within 7 weeks (not specified)**
Interventions	Effect of traditional training vs. PNF vs. NDT. 13 therapists participated in treatment and assessment of subjects, with first 5 clients assigned conventional treatment, the next 5 PNF, the next 5 NDT for 30-45 minutes a day for 5 days a week for 6 weeks.	Effect of biofeedback training vs. neurodevelopmental techniques (NDT). Both programs were 45 minutes long, 5 days a week for 5 weeks.	Effect of traditional training vs. neurodevelopmental techniques (NDT). Traditional training included passive, active, progressive resisted exercises for no less than 1 hour a day until discharge. NDT training was for same length of time
Outcomes	Differences measured by Barthel Index, muscle tone, active ROM	Upper Extremity Function Test (UEFT) finger oscillation test; Health Belief	Differences measured by Barthel Index; Manual Muscle Test
Notes	Questionable reliability and sensitivity of tone and range of motion measures; training of therapists described; no follow-up; Confounder of natural recovery	Small sample size; clear treatment protocols were designed and monitored; follow-up at 9 months.	Small sample size; therapists trained in delivery of each treatment; confounder of natural recovery; sensitivity of Manual Muscle Test
Critical appraisal rating	12/27	19/27	7/27

Summary of the evidence

Vanderlee et al. (1999) concluded that forced use therapy exerted a small but lasting effect on the dexterity of the affected arm (ARA) as compared with the NDT approach, Z =3.7, p>1.96.
Gelber et al. (1995) and Dickstein et al. (1986) both reported that no substantial advantage could be attributed to any of the treatment approaches, Z =0, p < 1.96.
Similarly, Logigan et al. (1983) and Basmajian et al. (1987) reported the lack of differences between the NDT approach and other treatment approaches, Z scores being -0.12 and 0.48 respectively, p <1.96.

Summary of the meta-analyses

Combing the available Z scores from five of the studies [Basmajian(1987), Dickstein(1986), Gelber (1995), Logigan (1983) and Van der lee (1999)] yielded a non-significant Z score of -1.49, p < -1.96 which indicated that neurodevelopmental techniques (NDT)were no more or less effective that other therapeutic approaches in treating the hemiplegic arm and hand.

Two studies [Lord (1986) and Van der lee (1999] administered questionnaires to stroke survivors that recorded their perceptions of the amount of daily activities done at home with the affected upper limb. Combing the calculated Z scores from these two studies yielded a significant Z score of -2.62, p > -1.96, indicating that clients reported better activity levels with other forms of treatment (force use and traditional functional training) than with NDT.

Table 5. Characteristics of included studies examining motor learning techniques in stroke survivors

Study	Hanlon, 1996	Platz et al., 1994	Winstein et al., 1999
Design	RCT Control (n=6) Random practice (n=9) Blocked practice (n=9)	Cohort Control (n=16) Treatment (n= 20)	Cohort Control (n=40) Treatment (n=40)
Methods	Random assignment appropriate. Outcome measures not blinded.	Outcome measures not blinded	No random assignment. Outcomes were not blinded.
Participants	CVA, n= 24; mean age 50.1 yrs; 2 centers; outpatients; minimum cumulative score of 30 on Fugl-Myer Arm	CVA; n= 36; mean age 54.4 yrs.; minimal paresis; rigidity, bradykinesia, dyskinesia, somatosensory impairment, perceptual, apraxic and other cognitive deficits excluded	CVA; n= 40; mean age 57.2 yrs.; volunteer outpatients; right-handed dominance; 35/40 had infarcts with anterior circulation system (MCA)
Time post stroke (mean)	**33.9 months**	**12.8 weeks**	**24 months**
Interventions	Effect of random practice vs. blocked practice on rate of acquisition and retention of a functional movement sequence. Random practice group had 10 practice trials per day on procedure alternated with 3 tasks of pointing, touching objects and spots in different planes with a 60 second rest. Blocked practice group had 10 practice trials in 2 blocks of 5 per day with 60 second rest; control group had no practice.	Effect of training on ability to perform motor learning tasks. Had kinesthetic training to learn (i) how to make triangular movements of a certain size and orientation performed with vision, (ii) 2 standard motor precision tasks (grooved pegboard and stylus-maze coordination), (iii) standard verbal and non-verbal learning task.	Effect of learning a discrete coordinated movement with the upper limb. Goal movement consisted of grasping handle at end of horizontal level and performing 2 elbow flexion and extension reversal movements. Augmented feedback provided after rapid movements under 2 conditions of 100% feedback or 67% faded feedback. Protocol was 2 phases: acquisition and retention for total of 198 practice trials
Outcomes	Differences measured by performance of experimental task that approximated opening cupboard door, getting coffee cup, etc.	Differences measured by kinematics	Differences measured by kinematics including root-mean square error and variable error.
Notes	Small sample size; random practice group younger and less months post stroke	Small sample size; subjects matched to sex, age, pre-morbid IQ and fluid intelligence; number of training trials kept low to avoid fatigue; no follow-up; laboratory setting; no functional outcome	Controls matched to age and hand dominance; no follow-up; subjects were assigned to 4 different feedback groups; laboratory setting; no functional outcome
Critical appraisal rating	9/27	13/27	13/27

Summary of the evidence

Hanlon (1996) found that there was a significant difference between the two groups on both retention tasks; the random practice was more effective than blocked practice, $p<0.01$ and $p=0.05$ respectively. Hanlon concluded that therapy that intersperses activities may be more effective in improving upper limb function than continuous repetitive training.

Platz et al. (1994) found that stroke survivors had longer movement times ($p<0.001$) and higher intra-subject variability on the tracing of two angles of the triangle than the control group. Both groups showed statistically significant training effects with retention immediately after training. The reached level of performance on the standard precision motor learning tasks was lower for the subjects with hemiparesis, with more mistakes on the stylus-maze coordination ($p <0.001$) and taking longer on timed pegboard task ($p <0.025$). The authors concluded that the capacity of stroke survivors to solve simple spatial -motor problems was preserved but motor control was less skillful and automatic.

Winstein et al. (1999) concluded that both groups demonstrated significant improvement in accuracy ($p<0.0001$) and consistency over practice. No differences between the two groups were observed in performance patterns during the acquisition, retention, or reacquisition phases. In addition, there were no differential effects of the two augmented feedback conditions on performances. There were no interactions of feedback condition with group. However, stroke survivors, independent of feedback condition, performed with more error than the control group during all experimental phases. It appeared that stroke survivors could learn the skills but had difficulty executing and controlling motor movements. These authors suggested that their study supported the capability of stroke survivors to behaviorally adapt (i.e. to improve in functional motor skills) despite relatively fixed physiological deficits.

Table 6. Characteristics of included studies examining the effectiveness of repetitive training in stroke survivors

Study	Butefisch , 1995	Dickstein et al., 1997	Mudie and Matyas, 1996	Whithall et al., 2000
Design	Cohort Control (n =15) Treatment (n=12)	Cohort Treatment (n=12) Control CVA , (15), normal (11)	Single subject (n= 8)	Case series (n=14)
Methods	Outcome measures not blinded. Multiple baseline design (ABAB) with cross-over for the control group (TENS to repetitive exs)	Outcome measures not blinded.	Multiple baseline AB design . Outcome measure not blinded. Random assignment of tapes, which were blinded to assessor.	Outcome measures not blinded.
Participants	CVA, n= 27; mean age 63.4 yrs; only patients with mild impairments and a minimum of selective hand & finger movements included.	CVA, n=27; mean age 70.5 yrs; 1 center; ability to flex paretic elbow for at least 5 degrees on a specially designed exercise board	CVA, n=8; mean age 69.3 years; 1 center; had to have most components of arm movement but no functional use.	CVA, n=14; mean age 63.8 years; 2 centers; antigravity movements in hemiplegic shoulder
Time post stroke (mean)	**8.5 weeks**	**4.9 weeks**	**17.1 weeks**	**30 months (median)**
Interventions	Effect of repetitive training + regular OT /PT vs. TENS + regular OT/PT. Phase A: Bobath treatment for 45 minutes daily + OT (5 hours a week). Phase B: repetitive training for grip, isotonic wrist extension finger flexion with wrist extension, 15 minutes twice daily. Control got TENS to wrist extensors for 15 minutes twice a day.	Effect of repetitive practice of elbow flexion and extension + regular treatment vs. exercises + regular treatment. Treatment group practiced 100 elbow flexion movements (10 series of 10) daily. Control group did a repertoire of exercises for 10 minutes every other day. Control normal received no treatment.	Effect of bilateral isokinematic training (BIT) vs. unilateral practice vs. bilateral practice with hands interlinked. Unilateral performance with paretic arm of block placement, simulated drinking, peg to eye level target. A was baseline for all three type of practice. BIT wa introduced in staggered order to each 3 actions.	Effect of bilateral arm training with rhythmic auditory cueing (BATRAC) on motor function. Training consisted of 20 minutes of BATRAC 3 times a week for 6 weeks (18 sessions). BATRAC was a specially designed bilateral arm trainer with two T-bars that moved in a frictionless transverse plane.
Outcomes	Differences measured in grip strength; isometric extension by force transducer; rapid isotonic wrist extension by accelerometer; function by Rivermead Motor Assessment.	Differences measured with Frenchay Arm Test, EMG, Kinematics, passive range of movement, Fugl-Meyer, sensation, Barthel	Visual inspection; joint analysis measured from photographs. PI one of the raters	Fugl-Myer Arm; Wolf Motor Function Test; University of Maryland Arm Questionnaire for Stroke (reliability not cited); isometric strength; active ROM.
Notes	Small sample size; No follow-up. Treatment group younger. During baseline all clients received Bobath treatment with no changes in measures.	No follow-up; small sample size; repetitive training of the elbow was not superior to conventional therapy in enhancing elbow movements.	Follow-up at 6 and 12 months (n=7); small sample size; Tested for autocorrelation. Test-retest and inter-rater reliability given for outcome measure	Follow-ups at 6 and 8 weeks after training (n =11); 2 drop-outs; small sample size; questionable feasibility of equipment
Critical appraisal rating	9/27	10/27	N/A	N/A

Summary of the evidence

Butefisch et al. (1995) reported that the indicators of motor performance (i.e. grip strength ($p<0.006$), peak force of isometric hand extensors ($p<0.05$), peak accelerations ($p<0.05$) of isotonic hand extensions as well as contraction velocities) significantly improved during the training period for both groups.

Dickstein et al. (1997) reported no significance difference between the two groups in any of the listed outcome measures.

Mudie and Matyas (1996) found that the performance on all three activities (lifting cube, simulated drinking, peg to eye level) improved significantly ($p<0.005$) with bilateral isokinetic training (BIT). The authors commented that baseline data indicated that therapist guided movement or the subject guiding the extremity with fingers interlinked was of little value in reducing active movement to passive movement. Follow-up at 6 months indicated that the gains in performance with BIT were maintained.

Whitall et al. (2000) showed significant improvement in the Fugl-Myer Upper Extremity Motor Performance Test ($p<0.0004$) with post-test and retention test effect sizes of 0.41 and 0.66 respectively. Similar gains were demonstrated in the Wolf Motor Function Test ($p<0.02$) with post -test and retention test effect sizes of 0.20 on both. Improvement was seen in isometric elbow flexion strength ($p <0.05$) and wrist flexion ($p<0.02$) and in active range of movement in shoulder extension ($p<0.01$), wrist flexion ($p<0.004$) and thumb opposition ($p<0.002$). Patient satisfaction, as measured by the University of Maryland Arm Questionnaire for Stroke, had effect sizes of 0.52 and 0.55 respectively.

Summary of meta-analyses

Data allowed an overall Z score to be calculated for functional ability, as measured by the Frenchay Arm Test and the Rivermead. Repetitive training appeared to have a small positive effect with an overall Z score of 2.07, $p > 1.96$ for the two studies [Butefisch (1995) and Dickstein(1997)].

Table 7. Characteristics of included studies examining sensory training in stroke survivors

Study	Yekutiel and Guttman, 1993	Aisen et al., 1997	Carey et al., 1993
Design	Cohort Control (n =19) Treatment (n=20)	Cohort Control (n =10) Treatment (n= 10)	Single subject design (n=8)
Methods	Outcome measures not blinded.	Patients and outcome measures blinded. Stratified on basis of impairment. Sham treatment.	AB multiple baseline design. Outcome measure not blinded.
Participants	CVA, n= 39; mean age 64 yrs; outpatients; one center; had major stroke with persistent sensory loss in hand	CVA, n=20; mean age 61 yrs; 1 centers; inpatients	CVA, n= 8, mean age 49.8 yrs.; free of unilateral neglect
Time post stroke (mean)	**6.2 years**	**3 weeks**	**13.5 weeks**
Interventions	Effect of retraining of sensory function on the paretic hand. Lessons of 45 minutes at home for 3 times a week that educated patient, had sensory tasks that the patient could do with stress on perception and vision (e.g. finding thumb, no. of lines drawn on forearm, blind discrimination of objects. Controls had no training.	Effect of robot-aided therapy vs. control. Both groups received conventional therapy. Treatment group received 4-5 hours per week of individualized robot-aided therapy with robot-assisted arm movement, visual and auditory feedback. Control group had biweekly contact with robot (sham treatment)	Effect of tactile and proprioceptive discrimination training on 4 multiple baseline experiments. No training in condition A. In condition B, subjects underwent 10 baseline tests 48-72 hours apart followed by 10 treatments on tactile, texture, and limb positioning of the affected upper limb.
Outcomes	Differences measured by location of touch, 2-point discrimination, stereognosis, sense of elbow position.	Differences measured in FIM, Fugl-Myer (arm); Motor Status Scale; Motor Power Scale (0-5).	Differences measured by Tactile and Proprioceptive Discrimination Tests
Notes	Small sample size; No follow-up. Differences in subject performance with right CVAs (n=10) making little change. Reliability of measures unclear. No evaluation of functional carry-over into every day activities.	No follow-up; small sample size; Control group had higher mean age and lower baseline FIM and F-M scores; reliability of Motor Power Scale not stated; pain occurring in 12/20 clients (but not measured prior to study).	Small sample size; Follow-up 3 and 5 months (n=7). Natural recovery, initial practice effects and nonspecific treatment effects may have impacted on baseline data.
Critical appraisal rating	8/27	16/27	N/A

Summary of the evidence

Yekutiel and Guttman (1992) reported that the treated group showed significant gains in all sensory tests ($p<0.001$) while no change occurred in the control group. However, those patients with right hemispheric strokes (n=10) showed consistently poorer gains than those with left hemispheric strokes (n=10) although their scores at onset were similar.

Aisen et al. (1997) reported that the robot-treated group showed a greater degree of improvement in all three measures of motor recovery with only change in the motor status of the proximal upper limb musculature significant (p=0.002). There were no adverse events resulting from the robot-assisted therapy.

Carey (1997) demonstrated through graphic and statistical interrupted time-series analyses that treatment produced improvement in seven out of eight tactile time series and all four proprioceptive time series.

Summary of meta-analysis

Effect sizes were calculated for the two cohort studies. They were 6.9 (Yekutiel & Guttman, 1993) and 2.3 (Ainsen et al., 1997) respectively. Combining the two effect sizes gives a statistical significant Z score of 5.38, p > 1.96 in favour of sensory retraining.

Table 8. Characteristics of included studies that examine sensorimotor training in stroke survivors

Study	Volpe et al, 2000	Volpe et al., 1999 (3 yr. Follow-up)	Feys et al., 1998	Jongbloed et al., 1989
Design	RCT Control (n =26) Treatment (n=30)	RCT Control (n =10) Treatment (n= 10)	Cohort Control (n=50) Treatment (n=50)	RCT Control (n=47) Treatment (n=43)
Methods	Random assignment & concealment appropriate. Outcome measures blinded.	Random assignment & concealment appropriate. Outcome measures blinded. Original study by Aisen et al., 1997	Subjects randomly assigned. Stratified according to Brunnstrum Fugl-Myer (FMA) staging. Outcome measures blinded.	Random assignment. Subjects and outcome measures were blinded
Participants	CVA, n=56; mean age 64.5 yrs; inpatients; one center; patients with sensory, cognitive, visual impairments were included	CVA, n= 12; mean age 60 yrs; one center; patients with sensory, cognitive, visual impairments were included	CVA; n= 100; mean age 64.2 yrs.; 6 centers; inpatients; included with FMA less than 46	CVA; mean age 71.3 yrs.; one center; patients were not severely aphasic
Time post stroke (mean)	**22 days**	**1016.1 days**	**22 days**	**40 days**
Interventions	Effect of additional sensorimotor training with robotic device (interactive device to move affected limb in real time) vs. sham treatment. Both groups received standard team treatment. Treatment group got 1 hour a day for 5 days a week (at least 25 hours) of robotic training. Control group received exposure to robot for 1 hour per week but 50% of the time with unaffected limb and the other half with hand over hand guidance.	Effect of additional sensorimotor training with robotic device (interactive device to move affected limb in real time) vs. sham treatment. Both groups received standard inter-disciplinary treatment. Treatment group got 1 hour a day for 5 days a week (at least 25 hours) of robotic training. Control group received exposure to robot for 1 hour per week but 50% of the time with unaffected limb and the other half with hand over hand guidance.	Effect of additional sensorimotor stimulation vs. control group. Treatment group had inflatable splint applied to hemiplegic upper limb while performing rocking movements in rocking chair with heels/ hand for 30 minutes daily/5 days/ week x 6 weeks. Control group had arm on lap for same period of time +short wave therapy to shoulder x 30 minutes while rocking with heels	Effect of sensorimotor integrative approach vs. functional treatment. Treatment group got sensorimotor treatment by trained OTs for 40 minutes daily for 5 days a week for 8 weeks. Control group received functional approach by OTs trained in this method for same period of time.
Outcomes	Differences measured by Motor Power score, Motor status, FIM, and Fugl-Myer Arm	Differences measured by Motor Power score, Motor status, FIM, and Fugl-Myer Arm	Differences measured by ARAT and FMA	Differences measured by Barthel Index; meal preparation; 8 subtests of Sensorimotor Integration Test
Notes	Subject characteristics (age, time post stroke, co-morbidities, pain, lesion size, etc.) well matched	Follow-up of 3 years; 40%; drop-out; small sample size; treatment group younger	8 drop-ups; follow-up at 6, 12 months; control group was 2.6 more post stroke ; adequate sample size	No follow-up; contamination with control group receiving Bobath treatment from PTs
Critical appraisal rating	13/27	12/27	19/27	15/27

Table 8. Characteristics of included studies that examine sensorimotor training in stroke survivors (continued)

Study	Aisen et al., 1997 (original to Volpe, 1999)
Design	Cohort Control (n =10) Treatment (n= 10)
Methods	Patients and outcome measures blinded. Stratified on basis of impairment. Sham treatment.
Participants	CVA, n=20; mean age 61 yrs; 1 centers; inpatients
Time post stroke (mean)	3 weeks
Interventions	Effect of robot-aided therapy vs. control . Both groups received conventional therapy. Treatment group received 4-5 hours per week of individualized robot-aided therapy with robot-assisted arm movement, visual and auditory feedback. Control group had biweekly contact with robot (sham treatment)
Outcomes	Differences measured in FIM, Fugl-Myer (arm); Motor Status Scale; Motor Power Scale (0-5).
Notes	No follow-up ; small sample size; Control group had higher mean age and lower baseline FIM and F-M scores; reliability of Motor Power Scale not stated; pain occurring in 12/20 clients (but not measured prior to study).
Critical appraisal rating	16/27

Summary of the evidence

Volpe et al. (2000) reported that the robot-trained group demonstrated improvement in motor outcome for the trained shoulder and elbow (Motor Power score, $p < 0.001$ and Motor Status score, $p < 0.01$). However, this did not generalize to the untrained wrist and hand, $Z = 5.27$ and 6.48, $p > 1.96$ respectively).

In a 3 year follow-up study on the original 20 stroke survivors who were randomized to either the robot or the sham treatment, Volpe and colleagues (1999) found that the robot-trained group (n=6) maintained their gains and showed significant decreases in impairment in their affected shoulder and elbow (Motor Power score, $p < 0.05$; Motor Status score, $p < 0.05$, $Z = 6.5$, $p > 1.96$) than the control group (n=6). However, there was no difference between the two groups on the Fugl-Meyer, $Z = 1.66$, $p > 1.96$ with both groups making the same amount of change.

Feys et al. (1998) reported that there were significant differences between the two groups at 6 months ($p = 0.004$) and at 12 months ($p = 0.03$) on the Motor Status Test for shoulder and elbow, $Z = 3.15$ and 3.16 respectively, $p > 1.96$; this showed a group by time interaction in favour of the treatment group. There was no difference between the two groups on the Action Research Arm Test, $Z = 0.317$, $p > 1.96$.

Jongbloed et al (1989) did not find any statistically significant differences between the two outcome groups on the three outcome measures.

Summary of the meta-analysis

The overall Z score at the end of the treatment phase (Volpe 2000; Fey, 1998; Jongbloed, 1989) was significant, Z =4.78, p >1.96, in favour of the treatment group that received sensorimotor training. Calculating a Z score from the two studies that followed subjects for 12 months (Feys, 1998 and Volpe, 1999), there was still a significant effect in favour of the treatment group, Z =6.83, p > 1.96.

Table 1. Characteristics of included studies of EMG-electrical stimulation of wrist and forearm in stroke survivors less than 6 months post stroke

Study	Heckmann, 1997	Bowman and Baker, 1979	Francisco et al., 1998	Van Overeem Hansen, 1979
Design	Cohort Control (n=14) Treatment (n=14)	Cohort Control (n=15) Treatment (n=15)	RCT Control (n=5) Treatment (n=4)	Case series (n= 12)
Methods	Randomization not specified. Unclear whether outcome measure was blinded. No sham treatment	Randomization not specified. Unclear whether outcome measure was blinded. No sham treatment.	Allocation of random assignment concealed. Outcome assessment was blinded. No sham treatment	Outcomes not blinded
Participants	CVA, n=28; mean age 52 yrs; single center; all inpatients; there were no significant differences between EMG-NMS and control subjects	CVA, n=30; mean age N/A; Volunteers; characteristics of the subjects in both groups not reported. Subjects needed between 5°-30°degrees of active wrist extension.	CVA, n=9, mean age 64.5 yr.; single center; first, unifocal non-hemorrhagic CVA; difference in laterality (3/ 4 in treatment group were right CVA vs. all left CVA in control group)	CVA; n=11 (including bilateral wrists)
Time post stroke (mean)	56 days	3 weeks –4 months (not specified)	Within 2 weeks	3 weeks
Interventions	Effect of regular treatment (Bobath based) for 45 min. times 5 per week vs. EMG-NMS + regular treatment (Bobath based for 45 min. x 5 per week. Surface EMG-NMS over wrist extensors 5 times a weeks for 4 weeks.	Effect of rehabilitation treatment vs. regular treatment + positional feedback and electrical stimulation. Control group had regular treatment for 5 days per week for 4 weeks. Positional feedback and electrical stimulation 1 hr per day.	Effect of regular rehabilitation + matched time vs. regular rehabilitation+ EMG-NMS. Regular treatment both groups. EMG-NMS twice a day for 30 min for length of stay Control group received additional exercises twice a day for 30 minutes for length of stay.	Effect of EMG-FES on the paretic hand. No other treatment noted. EMG-FES placed on extensor site (not specified).
Outcomes	Measured post -treatment: difference in spasticity by the Pendulum test; active range of movement (0-5); Barthel.	Measured post-treatment; difference in wrist extension torque and active range of movement.	Measured post-treatment: difference in Fugl-Myer Arm and feeding, grooming, upper extremity dressing of FIM	
Notes	No reported reliability for active range of motion score; treatment group had greater intensity of treatment; both groups improved except for spasticity in control group. Difference in Barthel Index not significant	No follow up; unequal treatment intensity.	No follow-up. Small sample size. Treatment group had lower baseline FMA scores and stayed longer in rehabilitation	Small sample size. no follow-up;.patients' characteristics not described; Intensity and duration of treatment not described.
Critical appraisal rating	16/27	5/27	20/27	N/A

Summary of the evidence

Bowman and Baker (1979) reported that at the end of a 4-week program, the treatment group showed a 280% increase in isometric extension torque when the wrist was positioned in 30° of extension and a 70% increase when the wrist was positioned in 30° of flexion. The treatment group made an average 200% gain in selective range of motion over their starting levels while controls only made a 50% increase.

Francisco et al. (1998) reported that subjects who were treated with EMG-stimulation exhibited significantly greater gains in the Fugl-Myer (27.0 vs. 10.4; p=0.05) as compared to the controls.

Heckman et al. (1997) reported that the treatment group showed significant improvement in the range of motion of the hand p=0.0095). The degree of spasticity, movement and the Barthel Index of the treatment group were superior to the control group but not significantly.

Summary of meta-analysis

The effect sizes for the above three studies outlined in Table 2 were 0.55 (Heckman, 1997), 1.66 (Francisco, 1998), and 0.864 (Bowman, 1979). Combing these effect sizes gave an over-all Z score of 3.43, p > 1.96, confirming a treatment effect in favor of EMG-NMS over treatments in the control groups.

Table 2. Characteristics of included studies of biofeedback-electrical stimulation of the wrist and forearm in stroke survivors greater than 6 months post stroke

Study	Cauraugh et al., 2000	Kraft et al., 1992	Taylor, 2000	Dimitrijevic et al., 1996
Design	Cross-over cohort Control (4) Treatment (6)	Cohort Control (n=5) EMG-NMS (n=6) PNF (n=3) Low intensity ES (n= 4)	Single subject (ABA) (n=1)	Case series (n=11)
Methods	Random assignment not specified. Outcome measure not blinded. No sham intervention	No randomization. Outcome measure not blinded. No sham treatment.	Outcome measurement from photographs; study conducted in home	Outcome measure not blinded. Follow-up at 3.9 months. ICC conducted for kinematics and EMG variability
Participants	CVA volunteers, n=10; mean age 61.4 yrs; single center; subjects were not receiving rehabilitation; subjects had wrist extension 20° vs. gravity from 90° flexion. Subject characteristics not reported.	CVA, n=18; mean age 62.8 yrs; Outpatients; Difference noted between control and EMG-NMS subjects in age and baseline FM scores.	CVA	CVA; mean age 63 yrs; patients were not receiving active treatment
Time post stroke (mean)	3.5 years	2.1 years	2.5 years	1.8 years
Interventions	Passive range of movement & stretching to both groups. EMG-NMS over extensor digitorum communis & extensor carpi ulnaris for 2 ½ hour sessions.3 x week, for total of 12 sessions. Control group performed active wrist extension for 2 sessions of 30 trials.	Surface EMG-NMS face over wrist extensors (not specified) for total of 36 1- hour sessions. Low intensity tens group over wrist extensor for 30 minutes x 5 per week for 3 months. PNF group had total of 36 1- hour sessions. Control group had no treatment.	Baseline measurement for 7 days followed by NMES to the left elbow daily for 2 months. Amount of time not specified.	Application of a mesh glove with different protocols that varied the amount of stimulation intensity for different subjects. All patients wore mesh glove for 4-6 wks. for 20-30 minutes at sub-threshold sensory levels.
Outcomes	Measured after treatment: difference in Fugl-Meyer Motor Assessment (FM); Box and Block; Motor Assessment Scale	Measured at 3, 9 months difference in Fugl-Myer (FM), grip strength (Jamar hand dynamometer, Jebson-Taylor Hand Function Test; Reitan finger tapping (not reported).	Unsure as to the reliability of the outcome measures. No significant result.	EMG activity and kinematics
Notes	Small sample size of volunteers. Unable to determine initial motor impairment for the two groups. Only six hours total of EMG-NMS treatment.	Number of dropouts (n=4); EMG-NMS group were younger and had higher pre-test FM scores as compared to control group. Small sample size. Long follow-up.		Daily stimulation increased wrist extension movement and amplitude in those subjects with some voluntary movement
Critical appraisal rating	12/27	12/27	N/A	N/A

Table 2. Characteristics of included studies of biofeedback-electrical stimulation of the wrist and forearm in stroke survivors greater than 6 months post stroke (Continued)

Study	Smith et al., 1990
Design	Case series (n=24)
Methods	Outcome measure not blinded
Participants	CVA; n=24; mean age 55.2 yrs; single center; clients were not receiving rehabilitation.
Time post stroke (mean)	1.8 years
Interventions	Effect of patterned functional electrical stimulation (PFES). Each PFES program was computerized from individual profiles of EMG measurements. 18 1 hr. sessions of PFES for 3 times a week for 6 weeks. PFES over biceps and triceps.
Outcomes	Measured differences after treatment in active range of movement
Notes	Small sample size; no follow-up; reliability of video-taping for measurement; patient characteristics not fully described
Critical appraisal rating	N/A

Summary of the evidence

There was insufficient available data to calculate an effect size or Z score for Cauraugh et al. (2000). The authors reported a significant effect of EMG-NMS on lifting blocks with the treatment group lifting 9 more blocks after treatment than before ($p < 0.05$). Improvement in force generation did not translate into functional improvement.

In Kraft's study (1992), examining the efficacy of EMG-FES (n=6) versus the group that received no treatment (n=5), the Z score (4.2) was significant. However, the EMG-NMS group had higher admission FM scores. The PNF group (n=3) with FM admission scores similar to the EMG-NMS group was combined with the control group, making an n of 8. When the Z score was recalculated between the EMG-NMS group and the combined PNF and control group, it lacked significance (Z=1.32) at 3 months and at 9 months (Z=0.53, n=12). Comparing the group that received low-intensity electrical stimulation (n =4) with the EMG-NMS group, there was no treatment effect, Z= -1.27 at 3 months, and Z=-1.04 at 9 months (n=9). Comparing grip strength in the three treatment groups, the EMG-stimulation subjects changed the most from pre-treatment to post-treatment but their improvement was not significantly greater than the improvement that received either PNF or low frequency electrical stimulation.

Smith et al., 1990 reported that active range of movement in the upper limb improved by 90%, p=0.05.

Table 3. Characteristics of included studies of electrical stimulation of the wrist and forearm in stroke survivors

Study	Chae et al., 1998	Powell et al., 1999	Pandyan and Granat, 1997	Hummelsheim et al., 1997
Design	RCT Control (n=14) Treatment (n=14)	RCT Control (n =23) Treatment (n=25)	Case series (n=11)	Case series (n=12)
Methods	Randomization by computer-generated random number table. Outcome measure blinded. Placebo stimulation	Randomization by computer generated Random number table. Outcome measure blinded. No sham treatment.	No random assignment. Partial effort to blind subjects to interventions	No random assignment. Outcome measurement not blinded. Multiple baseline design.
Participants	CVA, n=28; mean age 60 yrs; single center; all inpatients; there were no significant differences between NMS and placebo subjects	CVA, n=48; mean age 67.7 yrs; single center; no significant differences between NMS and control subjects; subset of 33 (control= n of 18; treatment n=15) with measurable residual wrist extensor strength.	CVA, n=11, mean age 74; single center; subjects had reduced range of motion in wrist or wrist flexion contracture	CVA, n=12, mean age 59.5 yrs.; CT confirmed ischemic lesions in MCA territory
Time post stroke (mean)	2.2 weeks	3.3 weeks	24 weeks	7.6 weeks
Interventions	Sham treatment + standard rehabilitation vs. NMS + standard rehabilitation. Surface NS over extensor digitorum communis & extensor carpi ulnaris from 1 hour per day for 15 sessions	Standard rehabilitation treatment vs. standard treatment+ NMS. Surface NMS over extensor carpi radialis longus & brevis, extensor carpi ulnaris, extensor digitorum communis for 3 x ½ hr. sessions (total 90 min.) for 8 weeks.	Regular rehabilitation for 2 weeks, then electrical stimulation (x 4 per day for 30 min to wrist), then two weeks of rehabilitation only. No follow-up.	Effect of repetitive ES of the extensor and flexor carpi radialis on hand performance & function. Baseline of usual treatment (Bobath) up to 3 weeks; ES for 20 minutes twice daily for 2 weeks; then repetitive training for two weeks..
Outcomes	Measured at 4 and 12 weeks: difference in Fugl-Meyer Motor Assessment (FM); FIM	Measured at 4,8,20,32 weeks; difference in Action Research Arm Test (ARAT); resting wrist angles; active range of movement, isometric strength of wrist extensors; modified Ashworth scale; grip strength; 9 hole peg test (not used).	Electrogonimeter to measure resting posture of wrist, maximal range of passive wrist extension, resistance to passive extension, and threshold angle	Rivermead Motor Assessment; Modified Ashworth; grip strength
Notes	Intention to treat analysis should be used because of high level of drop-outs (n=18) from original of 42 enrolled; control group had more cortical strokes vs. treatment group; small sample size.	Intention to treat analysis should be used because of high dropouts (n=12) from 60 enrolled; NMS group received greater treatment intensity; no statistical difference between groups with ARAT sub-scores of grip and pinch at week 32.	Two weeks of ES temporarily improved wrist posture and passive range of wrist movement but gain was immediately lost.	Electrical stimulation did not impact on Rivermead Motor Assessment and grip strength (NS). Visual analysis showed decreased spasticity ES and repetitive exercises.
Critical appraisal rating	25/27	22/27	N/A	N/A

Summary of the evidence

When comparing the treatment group to the control group, Powell et al. (1998) reported a trend towards significance (p=0.11) in the total ARAT scores in favour of the treatment group. A device with a built-in potentiometer was designed to measure isometric strength of wrist extension and active and passive ranges of motion at the wrist. The total treatment group (n=25) showed improved wrist torque at 8 (weeks p=0.004) and at 32 weeks (p=0.014) compared to the total control group. There was no difference in grip strength as measured by a Jamar hand dynamometer between the two groups.

Pandyan and Granat (1997) reported that short-term electrical stimulation gives temporary improvements in contractures at the wrist in post stroke hemiplegia, p=0.008.

Hummelsheim et al. (1997) reported that electrical muscle stimulation does not improve biomechanical or functional motor parameters.

Summary of meta-analysis

Effect size was calculated for a subset of 33 subjects who had residual wrist extensor strength that was measurable at the time of entry into Powell's (1999) study. When this effect size (1.2) was combined with the effect size of Chae's (1998) study (0.64), statistical analysis resulted in a significant treatment effect (Z = 2.44, p >1.96, in favour of using electrical stimulation with the hemiplegic arm and hand.

Table 1. Characteristics of included studies examining force use in stroke survivors

Study	Dromerick et al., 2000	Vanderlee et al., 1999	Taub et al., 1993	Miltner et al., 1999
Design	RCT Control (n =9) Treatment (n=11)	RCT Control (n =31) Treatment (n= 31)	Cohort Control (n=5) Treatment (n=4)	Case series
Methods	Random assignment & concealment appropriate. Outcome measures blinded.	Problems with randomization assignment. Concealment appropriate. Outcome measures blinded.	Subjects randomly assigned. Outcome measure blinded.	Outcome measures and subjects not blinded
Participants	CVA, n=20; mean age 66.5 yrs; inpatients; one center; subjects had some paresis; hemorrhagic strokes excluded	CVA, n=62; mean age 61 yrs; 5 centers; outpatients; subjects had a minimum of 20°of active wrist extension and 10°finger extension; ARAT score <51.	CVA, n= 9, median age 65; outpatients; subjects had a minimum of 20°of active wrist extension and 10°finger extension; no balance problems	CVA, n=15; mean age 54 yrs.; outpatients; subjects had a minimum of 20°of active wrist extension and 10°finger extension
Time post stroke (mean)	**6 days**	**3.0 years**	**4.5 years (median)**	**5.1 years**
Interventions	Effect of constraint-induced movement (CIM) vs. traditional therapy. Mitten on good hand outside therapy for at least 6 hours/ day for 14 days + ADL therapy + CIM training for 2 hours/ day, 5 days a week for 14 days. Control group had same intensity and time but did UE strength, ROM, compensatory techniques, and circuit training with bilateral ROM.	Effect of forced use therapy vs. bimanual training (NDT). Unaffected arm immobilized with sling + mitt for 12 days, 90% of the day. Control group received bimanual activities, posture exercises, and decrease of abnormal tone (NDT) for5 days/week for 6 hours for 2 weeks. Group activities, attention, exercises equally divided between the 2 groups.	Effect of forced use therapy vs. control group. Unaffected arm and hand immobilized in resting splint + sling for 90% of day for 14 days + 6 hours/ day of upper limb activities. Control group received 10 minutes attention to UE x 4/day + 2 PT sessions excluding UE + 15 minutes of home exercises (self ranging)	Effect of forced use therapy vs. control group. Unaffected arm and hand immobilized in resting splint + sling for 90% of day for 14 days + training (shaping) during the 8 weekdays. Shaping involved a battery of 50 tasks rewarded with positive reinforcement.
Outcomes	Differences measured by ARAT and Barthel	Differences measured in ARAT, Fugl-Myer (arm); Motor Activity Log; Rehabilitation Activities profile	Differences measured by ARAT, Emory Motor Ability, Motor Activity Log	Wolf Motor Function Test; Motor Activity Log
Notes	Small sample size; No follow-up. Differences in subject characteristics with treatment group younger (p=0.07). Three subjects in the traditional group dropped out.	Follow-up for 1 year; Differences in subject characteristics with treatment group having higher scores in all measures at the beginning of the study. Intention to treat analysis showed no significant difference between the two groups.	Small sample size; 1 drop-up; follow-up with Motor Log Activity for 1 year; 3 out 4 subjects in treatment group complained of joint stiffness and pain half-way through protocol.	Small sample size. Follow-up at 4 weeks and 6 months;(n= 12) Treatment effect noted regardless of hand dominance.
Critical appraisal rating	16/27	22/27	12/27	N/A

Table 1. Characteristics of included studies examining force use in stroke survivors (continued)

Study	Liepert et al., 2000	Ostendorf and Wolf, 1981
Design	Case series (n =13)	Single subject design (n of 1)
Methods	Outcome measures blinded.	Outcome measures blinded.
Participants	CVA, n=13; mean age 57.6 yrs; outpatients; subjects had a minimum of 20°of active wrist extension and 10°finger extension	CVA, n=1; age 50 yrs; outpatients who had just finished treatment
Time post stroke (mean)	4.9 years	1.5 years
Interventions	Effect of constraint-induced movement to assess therapy-induced plasticity. Resting hand splint and sling on unaffected upper limb for a target of 90% of the waking hours. Six hours per day of behavioral "shaping".	Effect of forced use therapy on quantity and quality of functional behavior. ABA design. A, baseline, for 7 days; B phase intact upper limb restrained using shoulder sling with only daily passive range of movement for 7 days
Outcomes	Differences measured by focal transcranial magnetic stimulation (TMS); Motor Activity Log	Differences measured in quality of movement (0-5); functional activities and time to complete activities.
Notes	Small sample size; Three dropouts. Follow-up on 8 subjects.	Follow-up for 2 and 4 weeks after study. Standardized measure of functional activities not used. **No difference observed in measures.**
Critical appraisal rating	N/A	N/A

Summary of the evidence

Only one study (Dromerick et al., 2000) was done in the acute setting. Dromerick et al. (2000) compared change scores in Action Research Arm Test (ARAT) two weeks after the completion of the study and found that constraint-induced movement compared to traditional upper limb therapies was more effective with an effect size of 0.66 and a significant Z score of 9.66, >1.96.

Data was not obtainable from Taub et al. (1993) to calculate the effect size, odds ratio, or Z score.

Effect sizes were calculated for Vanderlee (1999's study at varying times: (a) 0. 66 at pre-start of the study; (b) 0.46 at week 0; 0.66 at week 3; 0.52 at week 6; and 0.55 at 1-year follow-up. There were significant Z scores during the course of the study, 3.7 at week 3, 4.05 at week 6, and 2.56 at 1-year, p>.96 which indicated that force-use treatment exerted a small effect on the functional ability of the hemiplegic arm and hand. These chronic stroke survivors had at least 20° wrist extension and 10° MCP extension in the affected hand. Caution is needed in reviewing these results as the forced-use group had higher ARAT and Fugl-Myer Arm scores prior to the beginning of the study. Difficulties with randomization resulted in differences in

patient characteristics. Intention-to-treat analysis, based on the original allocation of subjects within the study, resulted in no difference between the two groups.

Miltner's study had an effect size of 0.89.

Liepert's (2000) study focused on the reorganization of the motor cortex of stroke patients that were treated with 12 days of constraint-induced movement therapy. Using transcranial magnetic stimulation, Liepert et al. demonstrated that after the first day of force use, there were 37.5% more active positions in the infarcted hemisphere than in the non-infarcted hemisphere ($p = 0.002$). Four weeks after treatment, the motor output map of the affected side was still significantly larger than before therapy ($p = 0.036$).

Taub et al. (1993) visually displayed the improvement made by the forced treatment group on various tests of motor function. Stroke survivors reported that these gains were maintained during a two-year follow-up.

Four studies reported significant improvement on the Motor Activity Log (Liepert, Miltner, Vanderlee, Taub) where real world outcome was assessed through a semi-structured interview that obtained information about 20 important activities of everyday living that were carried out at home (e.g. dressing, feeding, grooming, etc.). The effect sizes for Liepert and Miltner were 1.5 and 2.15 respectively.

Summary of meta-analyses

Combining the effect sizes of the two studies (Dromerick &Vanderlee) gave a significant Z score of 9.71, p> 1.96, which suggests that constraint-induced movement therapy or force use was associated with more upper limb function at the end of the treatment period.

Combining the effect sizes on the Motor Activity Log from the studies of Vanderlee (1999) and Taub (1993) indicated that force-use had a significant effect on the clients' level of activity at home with the unaffected upper limb, Z score of 11.10, p >1.96. Again, these clients began with a minimum of 20° wrist extension and 10°MCP extension

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Table 1. Characteristics of included studies examining the use of acupuncture in stroke survivors

Study	Wong et al., 1999	Naeser et al., 1994	Hopwood and Lewith, 1997
Design	RCT Control (n =59) Treatment (n=59)	Cohort Control (n =2) Treatment, chronic (n=8), acute (n=3)	Single subject design (ABCBC) (n of 6)
Methods	Random assignment & concealment not reported. No sham treatment. Outcome measures not blinded.	Randomization not clear. Outcome measures blinded. No sham treatment.	Reversal of order of treatment in 2 out of 6 subjects. Outcome measure blinded. Placebo intervention.
Participants	CVA, n=118; mean age 60.4 yrs; inpatients physically stable within 10-14 days post onset; one center; clients had some paresis; hemorrhagic strokes excluded	CVA, n=13; mean age 63.4 yrs; 1 center; clients had some hand paresis without significant arm paresis; all had left CVAs; no hemorrhage in acute cases; only 1 acute subject receiving therapy.	CVA, n= 6, median age 71.3 years; were outpatients with moderate to severe strokes
Time post stroke (mean)	**10-14 days**	**chronic 47 months, acute 2 months**	**3.4 months**
Interventions	Effect of electrical acupuncture + comprehensive rehabilitation vs. comprehensive rehabilitation. Electrical acupuncture for 30 minutes for 5 times a week for 2 weeks. Multi-disciplinary treatment of OT/PT (not specified) for 2 hours each day until discharge	Effect of acupuncture (with needles) on the treatment of hand paresis. Chronic subjects received acupuncture 2-3 times a week over 2-3 months. Acute subjects received 5 daily treatments per week for 1-2 months. All patients received a minimum of 20 treatments (5 received 20, 6 got 40 sessions). Control received no treatment.	Effect of acupuncture (with needles) on upper limb function. Daily 30-minute treatments for two months, alternating between 2 weeks of acupuncture and 2 weeks of placebo intervention.
Outcomes	Differences measured by Brunnstrum stages and Chinese version of FIM	Differences measured in Jebson and Taylor subtests of timed dexterity; tip pinch, 3-jaw chuck, lateral pinch; handgrip strength; time to copy one sentence.	Differences measured by Motricity index, Rivermead Motor Test, Nine hole Peg Test, (not used); pain (visual analog)
Notes	No follow-up. Subject characteristics of both groups well matched. Shorter hospitalization time for treatment group. Within window of high motor recovery.	Small sample size. Follow-up at 2 and 4 months (n=6). Good response in subjects with lesions in only half, or less than half of the motor pathways areas on CT scan. Untreated controls also showed improvement. Intensity of treatment not consistent.	Small sample size; difficulty with reliability of outcomes due to videotaping as a method to blind assessment; 4 subjects complained of shoulder pain but pre-treatment status was not evaluated.
Critical appraisal rating	12/27	15/27	N/A

Summary of the evidence

Wong et al. (1999) reported that patients treated with electrical acupuncture had a shorter hospital stay in rehabilitation and better neurological outcomes than the control group in scores of self -care and locomotion (p=0.02). Changes in the motor stages of the upper limb, as measured by Brunnstrum staging, were not significant (p=0.15). The experimental group's

neurological status for the upper limb changed from 2.3 (0.8) to 3.2 (1.1) while the control group's staging changed from 2.1 (0.6) to 2.6 (0.9).

Naeser et al. (1994) reported that acupuncture may be an additional beneficial treatment with improvement seen in motor strength (n= 11) on tip pinch ($p<0.02$), 3-jaw chuck ($p<0.002$) and lateral pinch ($p<0.04$) as measured by a pinch meter. Handgrip increased ($p < .03$). However, the authors observed that good response was seen in stroke survivors who had lesions in less than half the motor pathway and in those clients who had only mild to moderate hemiparesis.

As there were only 2 controls in the study by Naeser (1994), it was not possible to calculate an over-all Z-score.

Hopwood and Lewith (1997) showed that the rate of change as indicated by the slope of the graph clearly varied with the acupuncture and placebo interventions; there were often steeper slopes with acupuncture. However, the authors stated that the use of videotapes in an effort to blind the observers made it difficult to interpret the performance.

Table 2. Characteristics of included studies examining the efficacy of botulinim toxin type A (BT-A) on spasticity in stroke survivors greater than 6 months post stroke

Study	Hesse et al., 1998	Bhakta et al., 2000	Lagalla et al., 2000	Sampaio et al.,1997
Design	RCT Placebo (n=4) Placebo + ES (n=6) BT-A (n=6) BT-A + ES (n= 6)	RCT Placebo (n= 20) BT-A (n= 20)	Case series (n=28)	Case series (n=19)
Methods	Random assignment appropriate but not clear as to concealment Outcome measures and subjects blinded. Placebo intervention	Random assignment appropriate with concealment .Outcome measure and subjects blinded. Placebo intervention.	Effect of BT-A . Outcome measure blinded.	Effect of BT-A. Outcome assessment not blinded.
Participants	CVA , n=24; mean age 52.3 yrs; single center; not receiving rehabilitation; upper extremity nonfunctional. Fixed contractures, previous BT-A treatment or surgical procedures excluded.	CVA, n=40; mean age 57 yrs; single center; not receiving rehabilitation; upper extremity had to be nonfunctional. Fixed contractures, previous BT-A treatment or surgical procedures excluded.	CVA, n= 28, mean age 58.9 years, 23 clients with ischemia. Fixed contractures, previous BT-A treatment or surgical procedures excluded	CVA; mean age 53 yrs; not attending active treatment. 11 subjects receiving physiotherapy while enrolled in study
Time post stroke (mean)	7.5 years	3.1 years	2.6 years	3.3 years
Interventions	Four treatment arms. Placebo or BT-A was 500 units x2 injected under EMG guidance into forearm and wrist flexors. Electrical stimulation was in ½ sessions for 3 hours per day during the three days following injection.	1000 units of BT-A or equivalent placebo	50 units of BT-A under EMG guidance to forearm and hand flexors. Subjects had formal PT for 1 hour twice a week including prolonged stretching & passive mobilization.	Mean dosage of BT-A was 92.1 units in six forearm and hand flexors.
Outcomes	Measured after treatment and at 2,6 and 12 week intervals; difference in Modified Ashworth, limb position at rest; delivery of personal hygiene care	Measured after treatment and at 2,6 and 12 week intervals; difference in Modified Ashworth, pain, joint range of movement, muscle power (Medical Research Council);caregiver burden	Modified Ashworth, Frenchay arm test, Activities Test, range of passive movement and patient goals	Ashworth Scale, Frenchay arm Test. Frequency of spasms, severity of pain 90-5); passive joint mobility
Notes	Small sample size; Well matched in initial Ashworth score. Significant impact of placebo. No adverse effects reported.	Adverse effects in 3/40 clients. Reduction in muscle strength not noted with applied test. No analgesic effect but subjects not selected for this.	Follow-up 28 months. No impact on function. Initial change in spasticity in fingers after first injection but then no further changes.	Follow-up for 3 months. Adverse effects reported (? Number). Placebo effect may not be excluded.
Critical appraisal rating	19/27	26/27	N/A	N/A

Summary of the evidence

Bhaktra et al. (2000) reported that disability improved at week 6 with BT-A compared to the placebo. However, this effect, present at week 2, wore off by week 12. Forearm flexor spasticity was reduced with BT-A at week 2 but this significant improvement was not seen at weeks 6 and 12 compared to the placebo. Grip strength was reduced with BT-A. Bhata et al. (2000) reported a decrease in caregiver burden, occurring at 6 weeks and continuing until week 12. Although significant improvement in elbow flexor spasticity was seen at week 2 with BT-A as compared with the placebo, this effect was not evident at week 6 and 12. Arm pain was not improved with BT-A.

Hesse et al. (1998) reported that the placebo-controlled trial favoured the idea that electrical stimulation enhanced the effectiveness of BT-A in the treatment of chronic upper limb spasticity. The application of BT-A and electrical stimulation had a significant effect as compared to BT-A + placebo, Z= 3.05, p> 1.96. Hesse et al. (1998) noted that more studies need to be done to determine the role of electrical stimulation in either reducing spasticity or enhancing BT-A as this is unclear. An interesting observation was the placebo effect noted on spasticity as BT-A alone was no more effective than the placebo. The combined treatment of BT-A and electrical stimulation was superior to the other groups in terms of hand hygiene. Furthermore, this treatment impacted the most on the elbow joint. However, H-statistic revealed that there were no significant differences across groups for the Ashworth scores of the elbow, wrist, and fingers.

From the two case studies, 88% of the subjects showed improvement on the Frenchay arm Test (Lagalla, 2000 Sampaio, 1997). However, Sampaio et al. (1997) reported that stroke survivors rated the amount of change in the Frenchay to be minimal.

Summary of the meta-analysis

The Z scores for the cohort and RCT study were 0.34 (Bhata, 2000) and 0.85 (Hesse,1998) respectively at week 12. The overall Z score for comparing the effectiveness of BT-A alone versus a placebo group after a two week period was not significant, Z =1.05, P< 1.96.

Table 3. Characteristics of included studies examining the management of spasticity in chronic stroke survivors

Study	Carey, 1990	Lagasse et al., 1989	Kong and Chua, 1999	Mathiowetz et al., 1983
Design	Cohort Control (n =8) CVA control (n=8) Treatment (n= 8)	Case series (n =12)	Case series (n=20)	Cohort Normal control (n-8) Treatment (n =4)
Methods	Random assignment appropriate. Concealment unclear. Outcome measures and subjects blinded.	Outcome measure and subjects not blinded.	Outcome measure and subjects not blinded.	Outcome measures and subjects not blinded
Participants	CVA , n=24; mean age 55 yrs; outpatients ; clients demonstrated some spasticity but had at least 20° M CP extension. Eight normal subjects.	CVA, n=12; mean age 55.2 yrs; all clients had left CVAs and were not receiving rehabilitation	CVA, n= 2, mean age 62.8 years, outpatients; had severe elbow flexion contracture that were not responsive to other treatment; impaired walking secondary to elbow spasticity	CVA; mean age 30.7 yrs; clients had moderate to severe spasticity in hand and fingers; etiology mixed.
Time post stroke (mean)	5.9 years	1.7 years	1 year	7 years
Interventions	Effect of manual stretch on finger control and force control. Manual stretch of extrinsic finger flexors between pre/post tracking tests for 20 seconds for 5 minutes. Control CVA rested for 5 minutes between pre/post tracking tests.	Effect of FES training on spastic biceps during a maximal speed forearm extension movement. Biceps and triceps EMG activity monitored during forearm extension movement; treatment of 24 sessions of FES for 6 weeks and then retested.	Effect of musculocutaneous nerve block with 50% ethyl alcohol under guidance of neuromuscular simulator. Instructed in slow stretching to be done 3 times daily.	Compare immediate effects of volar resting splint, finger spreader, cone, and no device on normal and spastic hand. Before testing, subjects gave maximal voluntary contraction of grip; device worn for 2 minutes, rest and then tested.
Outcomes	Differences measured by Joint Movement Tracking Test (JMTT); Force Tracking Test (FTT); EMG	Differences measured pre and post FES treatment with EMG.	Modified Ashworth, Frenchay arm test, Activities Test, range of passive movement with goniometer	EMG activity
Notes	Small sample size; No follow-up. Differences in subject characteristics (impairment and function level) not described. Method of determining accuracy of outcome measures described.	Small sample size; No follow-up; Patterning of FES was adjusted for each patient after mathematical modeling of EMG parameters of the unaffected arm during the task.	Follow-up for 4 weeks and 3 and 6 months. Adverse effects in 3 subjects. Onset of shoulder pain reported in discussion for 4 subjects . Measurement protocol not described, giving assumption of spasticity and PROM being measured only once.	Inadequate methodology. Small sample size. Splints worn for brief period of time not reflective of clinical application. Normal subjects complained of discomfort wearing finger spreader.
Critical appraisal rating	13/27	N/A	N/A	10/27

Summary of the evidence

Carey (1990) reported that stretching of the extrinsic muscles improved joint movement tracking in the treatment group ($p < 0.05$); however, this stretching also increased spasticity in flexor digitorum superficialis with the EMG ratio increasing from 0. 29-0.34. There was temporary improved motor control. There was no significant change in the Force Tracking Test.

Mathiowetz et al. (1983) reported that there were no significant findings.

Lagasse and Roy (1989) reported that the application of the FES treatment resulted in improved forearm extension movement ($p< 0.01$) with a 372% degree increase, approximating the performance of the unaffected side (114° (12°) vs. 105.3° (22.1°). The time needed to reach maximal forearm extension decreased significantly ($p< 0.01$) by 72%. Peak value for biceps decreased significantly ($p <.01$) by 68% after FES treatment.

Kong and Chua (1999) reported that the application of a nerve block significantly decreased spasticity ($p<0.001$) in the affected elbow; this reduction was maintained over a 6-month period. Tone remained 54%, 46%, and 55% lower at 4 weeks, 3 and 6 months respectively. The passive range of motion of the elbow had improved by a mean of 15% over 6 months.

Table 4. Characteristics of included studies examining a variety of different modalities in stroke survivors

Study	Page, 2000	Paul and Ramsey, 1998	Smedley et al., 1986
Design	RCT Control (n =8) Treatment (n=8)	RCT Control (n =10) Treatment (n= 10)	Cohort Control (n=20) Treatment (n=25)
Methods	Appropriate randomization. Unclear to concealment. Unclear if outcome measures were blinded.	Outcome measures blinded.	Outcome measures not blinded.
Participants	CVA , n= 8; mean age 63.4 yrs; community volunteers; had a major stroke with no severe sensory or cognitive losses	CVA, n=20; mean age 61 yrs; were residing in a nursing home; Brunnstrum staging at least Stage 4; cognition good; had some limitation of shoulder movement	CVA, n=45; age between 40-80 yrs (no data); 2 centers; inpatients
Time post stroke (mean)	**1.8 years**	**93 days**	**not specified**
Interventions	Effect of imagery use + OT (NDT) vs. OT (NDT). OT for all patients 3 times/ week in 1/2-hour outpatient sessions for 4 wks. Treatment group were administered a 20 minute tape-recorded imagery intervention of external, cognitive, visual images. Control group watched general tape.	Effect of music making activity on improving shoulder flexion and elbow extension. Treatment group used music and electronic paddle drums adjusted for height for 30 minutes twice a week for 10 weeks. Control group received no music intervention but had PT (not specified).	Effect of slot machines + traditional OT vs. traditional OT; no clear description of treatment methodology
Outcomes	Differences measured by Fugl-Myer Arm.	Differences measured in active range of movement with Jamar goniometer	Range of motion, muscle strength, gross and fine motor skills (0-4).
Notes	Small sample size; No follow-up. Two dropouts.	No follow-up ; small sample size; lack of data on control group's mobility and other activities. Inter-rater reliability between the 2 OTs for measurement was 87%.	Intensity and nature of treatment in both groups not described. Measures were not reliable or valid.
Critical appraisal rating	14/27	17/27	6/27

Table 4. Characteristics of included studies examining a variety of different modalities in stroke survivors (continued)

Study	Page et al., 2001
Design	RCT Control (n =8) Treatment (n=5)
Methods	Random assignment by computer random table. Concealment not reported. Sham treatment. Outcome measures blinded.
Participants	CVA , n=13; mean age 64.4 yrs; outpatients volunteers ; 4 centers; some paresis; hemorrhagic or bilateral strokes excluded; clients had no serious cognitive deficits; able to image greater than 25 on Movement Imagery Questionnaire
Time post stroke (mean)	**6.5 months**
Interventions	Effect of imagery plus therapy vs. therapy. Upper and lower extremity exercises for 1 hour for 3 times a week for 6 weeks for both groups. Imagery + therapy group listened to 3 different 10 minute audiotape imagery interventions consisting of relaxation, progressive relaxation and suggestions of external visual images of using the affected limb in functional tasks. Therapy group listened to 10- minute tape containing stroke information. Compliance at home on weekends for both groups checked with telephone calls and logbook.
Outcomes	Differences measured by ARAT and FMA
Notes	No follow-up, small sample size; no statistical significance calculated; characteristics of groups not well described for confounders
Critical appraisal rating	16/27

Summary of the evidence

Page (2000) reported that those subjects receiving OT and imagery exhibited significantly more improved function than the control group ($p<0.05$). Effect size was calculated to be 1.39.
Paul (1998) reported no statistical difference in shoulder flexion and elbow extension between the two groups.
Smedley (1996) reported that there was no statistical difference between the two groups.
Page et al. (2001) reported that the therapy plus imagery group scores improved by 13.8 and 16.4 points respectively on the FM and ARAT. Calculated effect size the FM was 1.4 and 2.2 for the ARAT .

Summary of meta-analysis
Combining the effect sizes from Page (2000 and 2001) gave a significant Z score of 3.34, $p > 1.96$ in favour of imagery plus therapy.

Table 5. Characteristics of included studies examining the effect of orthokinetic treatment on the hemiplegic upper limb

Study	Neeman et al., 1993	Neeman et al., 1988	Neeman et al., 1992	Whelan, 1964
Design	Single subject (n =1)	single subject (n =1)	single subject (n =1)	case series (n=20)
Methods	ACABACAB. Counter-balanced interrupted time-series design with non-treatment (A), treatment (B), placebo (C1), sham treatment (C2) . Outcomes not blinded.	ACABACAB. Counter-balanced interrupted time-series design with non-treatment (A), treatment (B), placebo (C1) ,sham treatment (C2) . Outcomes not blinded.	ACABACAB. Counter-balanced interrupted time-series design with non-treatment (A), treatment (B), placebo (C1) ,sham treatment (C2) . Outcomes blinded.	Outcomes not blinded
Participants	CVA, n=1, age 49, male, right CVA infarct; subjects had no functional control of upper limb	CVA, n=1, age 60, female. left CVA infarct; hypertonus flexor synergy ; pain present; had no active movement	CVA, n=1, age 60, male. left CVA infarct; had active shoulder protraction and retraction; 25°active elbow flexion	CVA, n=20, mean age 56 yrs; 5 centres; baseline characteristics not clearly described
Time post stroke (mean)	26 months	30 months	6 years	25 months
Interventions	Effect of orthokinetic orthrosis (cuff-shaped dynamic orthopedic appliance which does not include rigid polymer or mental components) for 1 hour twice weekly for 26 wk.	Effect of orthokinetic orthrosis for 22 weeks. Additional PT of PROM exercises followed by AROM without stabilization of arm of shoulder by therapist	Effect of orthokinetic orthrosis for short periods of time followed by application for 12 weeks. Additional PT of PROM exercises followed by AROM without stabilization of arm of shoulder by therapist	Effect of orthokinetic segment on neuromuscular function. Patients extended forearm 30 times daily with weighted pulley alternating days with segment on and off.
Outcomes	Differences measured in active elbow range of movement with goniometer	Differences measured in active range of elbow extension; pain with McGill Pain Questionnaire	Differences measured in active range of elbow extension; pain with McGill Pain Questionnaire	Differences measured in active range of elbow extension, strength of elbow extensors, speed of reaction, postural carriage
Notes	Tested for serial dependency. No baseline data reported.	Confounder of active PT intervention on elbow	Confounder of active PT intervention on elbow	Questionable reliability of measures; carry-over effect; confounder of other treatment
Critical appraisal rating	N/A	N/A	N/A	N/A

Summary of the evidence

Visual inspection of the ACABACAB (Neeman, 1988,1992, 1993) showed mixed results. In the 1988 study, no change was noted during the first treatment phase but there was change in pain during the placebo periods. Subjects (n= 2) in the 1992 and 1993 studies showed improvement over the placebo treatment, $p = 0.01$ (two tailed test).

Whelan (1964) reported significant gains in elbow extension ($p < 0.01$) and in the carrying angle of elbow ($p < 0.05$).

Table 1. Characteristics of included studies examining electrical stimulation for preventing and treating post-stroke shoulder pain

Study	Price, 2001	Kobayashi et al., 1999
Design	Systematic Cochrane review on prevention and treatment. Treatment studies: Faghri (1994); Leandri (1990); Linn (1999); Sonde (1998)	Cohort Control (n =5) Treatment (Deltoid) (n= 6) Treatment (Supraspinatus) (n= 6)
Methods	Studies were evaluated on 11 methodological criteria including a comprehensive search, study criteria, selection bias, studies' internal validity, intention-to-treat analysis, Peto odds ratio, weighted and standardized mean differences	Outcome measures not blinded. Randomly assigned to treatment groups but method not stated.
Participants	CVA only, age range 45-84; 45% males; subjects with previous shoulder problems excluded; shoulder subluxation in 5-40%; loss of motor function	CVA; mean age 60.3 yrs; 2 centers; stress test to include only those subjects with downward shoulder subluxation; Brunnstrum staging was between 3 -5
Time post stroke (mean)	**<48 hours (Linn), 16.5 days (Faghri), 12 weeks (Leandri), 8.7 months (Sonde)**	115 weeks (60-190)
Interventions	Faghri : no sham treatment vs. FES Leandri: sham treatment vs. high intensity TENS vs. low intensity TENS Linn: no sham treatment vs. electrical stimulation (not FES or TENS) Sonde: no sham treatment vs. low frequency TENS (with muscle contraction)	Effect of therapeutic electrical stimulation vs. no treatment. All groups received traditional PT. Treatment group divided into two, with Deltoid stimulated in 1 group,surpaspinatus in the other group up to 15 minutes twice daily for 5 days per week for 6 weeks
Outcomes	Faghri: pain-free range of lateral rotation, arm function, EMG activity, degree of G-H subluxation, tone Leandri: pain-free range of gleno-humeral range Linn: pain-free range of lateral rotation, upper limb girth, Motor Assessment scale, degree of G-H subluxation Sonde: VAS for pain, Fugl-Myer, Modified Ashworth	No stress and stress x-rays, EMG; VAS for pain, Modified Ashworth
Notes	Search methods were clearly identified. Two referees and consensus to eliminate selection bias. Clear criteria for selection of outcomes. Sensitivity analyses planned a priori. Weighted treatment effects calculated. Small population numbers. Variance in time post stroke	Small sample size; no follow-up; shoulder pain in 42.1%. Mean time post stroke greater in control group; less impairment in control group;
Critical appraisal rating	7/7 Oxman-Guyatt Index	16/27

Table 1. Standardized scores of main parameters (Price, 2001)

First author	Parameter	Z -score
Linn (n =40)	ES vs. sham treatment	
	New reports of pain	-1.36
	Change in amount of external rotation	2.16
	Change in pain intensity	1.28
	Change in motor score	0.20
	Change in gleno-humeral subluxation	2.65
Faghri (n=26)	FES vs. control	
	Change in amount of external rotation	2.08
	Change in motor score	1.55
	Change in gleno-humeral subluxation	3.47
	Change in spasticity	0.87
Leandri (n=60)	High intensity TENS vs. sham treatment vs. low intensity TENS	
	Change in amount of external rotation	2.32
Sonde (n=44)	Low frequency TENS vs. control	
	New reports of pain	1.19
	Change in pain intensity	1.43
	Change in motor score	0.60
	Change in spasticity	0.44

Table 1. Main clinical findings of therapeutic studies (Price, 2001)

First Author	Outcome
Linn	Treatment group had significant less subluxation and pain after the treatment period but at the end of the follow-up period there were no significant differences between the two groups
Faghri	The experimental group showed significant improvement in arm function, electromyographic activity of the posterior Deltoid, range of movement and reduction in subluxation compared to the control group,
Leandri	Statistically significant improvements of passive range of movement was seen in the high-intensity TENS group but not in the control group or the low-intensity TENS group.
Sonde	Low TENS vs. control did not decrease either pain or spasticity but motor function increased significantly in the treatment group as compared to the control.

Table 1. Characteristics of included studies to treat post-stroke shoulder pain (continued)

Study	Dekker et al., 1997	Inaba and Piorkowski, 1972	Sonde and Kalimo, 2000
Design	Single subject, AB design (n =7)	RCT control sham (n=10) control ROM (n= 13) treatment (n= 10)	RCT control (n= 10) treatment (n -18)
Methods	Length of the baseline condition (A) was staggered and randomized (either 2 or 3 weeks) after confirmation of inclusion criteria. Outcomes not blinded	Randomization and concealment not described. Outcome measures blinded.	Randomization and concealment appropriate. Outcome measure not blinded .No sham treatment
Participants	CVA, mean age 61.9 years; had presence of shoulder pain with sleep; restriction of external rotation; minor subluxation in 1 subject (confirmed by x-ray)	CVA; mean age 58 years; single center; outpatients; had shoulder pain occurring between 0-90 °of flexion or abduction	CVA; mean age 70.4 years; single center; outpatients; 64% follow-up from previous study
Time post stroke (mean)	**3.2 weeks**	**4.6 months**	47 months
Interventions	Effect of intra-articular triamcinolone injections. Three injections of 40 mg. of the drug via the posterior route given on days 1, 8, and 22 of treatment. No changes made in the regular rehabilitation protocol.	Effect of ultrasound + l session of range of movement (ROM) and arm positioning vs. ROM+ arm positioning vs. ROM, arm positioning + sham treatment. ROM for all patients was self ranging with pulleys for 3 times a day for 4 weeks with pain -free positioning of arm with pillows, trough, slings; US for 5 minutes for 15 sessions	Effect of low frequency TENS vs. no treatment. Both groups received PT twice a week. Treatment group got low TENS for 60 minutes, 5 days a week for 3 months.
Outcomes	Visual analog scale for pain; MIE fluid-filled gravity goniometer; Ashworth; Fugl-Myer; Action Research Arm Test	Range of motion with goniometry	Fugl- Myer motor score; Modified Ashworth Scale; Barthel Index
Notes	Small sample size; no controls; no placebo; 22% drop-out; short follow-up; adverse effects of "flaring" reported in 5 out of 7 subjects; carry-over effects not assessed.	Small sample size; no follow up; confounder of exercise with ultrasound; did not measure intensity or occurrence of pain; placebo group had initial greater ROM in abduction with external rotation	Unequal numbers in groups. Treatment group began with higher Barthel scores; small sample size.
Critical appraisal rating	N/A	14/28	19/27

Summary of the evidence

Kobayashi et al. (1999) reported that, after 6 weeks of electrical stimulation of the supraspinatus and deltoid, there was a significant reduction in subluxation (p <0.05) observed in both treatment groups when compared to the control group; however, there had to be stress of a 3.5 kg. weight band placed around the distal portion of the arm , Z =3.59, p >1.96. These authors did not find a significant reduction in gleno-humeral subluxation when the joint was not under stress, Z =. 097, p < 1.96.

Summary of meta-analysis on reduction of gleno-humeral subluxation

When this finding from Kobayashi (1999) is calculated with the Z scores of Linn, 1999 (Z=2.65) and Faghri, 1994 (Z =3.47), there is a significant overall Z of 4.09, p > 1.96 indicating that electrical stimulation had an effect in decreasing gleno-humeral subluxation, even when not under stress.

Sonde and Kalimo (2000) reported a 3-year follow-up study that was included in the systematic review by Price (2001). There was no significant effect of low frequency TENS on performance on the Fugl-Myer ,Z = 0.63, p <1.96. Motor performance of the hemiplegic upper limb had deteriorated in both the TENS and control group over the 3-year period (-4.1 and -2.1 respectively). As well, the initial advantage that treatment with low TENS had given diminished during this time period. There was no significant effect of low frequency TENS on ADL performance as measured by the Barthel, Z =1.43, p <1.96. These findings agree with the results published by Price, 2000.

Summary of meta-analysis of the effect of low frequency -TENS on motor performance

There was no significant effect of low TENS treatment on motor performance, Z =1.33, p <1.96.

Sonde and Kalimo (2000) reported that over the 3-year span, spasticity increased in both the treatment and control groups by 0.6 and 0.3 respectively.

Summary of meta-analysis for the effect of electrical stimulation on spasticity

Overall Z score for the effect of electrical stimulation on decreasing spasticity was not significant (Z =1.52, p <1.96) when combined with the Z scores from Sonde, 1998 and Faghri, 1994 (Z scores of 0.44 and 0.87 respectively).

Summary of systemic Cochrane review

Price (2001) reported that there was no significant change in the incidence of pain, with an odds ratio of 0.64 (95% CI 0.19 - 2.14). There was no change in pain intensity with the standardized mean difference of 0.13 (95% CI -1.0-1.25) after electrical stimulation treatment as compared with the control group. There was a significant treatment effect in favour of electrical stimulation for improvement in pain-free range of passive humeral lateral rotation. The weighted mean difference was 9.17 (95% CI 1.43 - 16.91). In these studies, electrical stimulation reduced the severity of gleno-humeral subluxation with the standardized mean

difference of -1.13 (95% CI -1.66 to -0.60). There was no significant effect on upper limb motor recovery or limb spasticity. There did not appear to be any adverse reactions to electrical stimulation of the shoulder.

Inaba and Piorkowsky (1972) reported no significant difference in reduction in pain as measured by change in range of motion, Z = 0.4, p < 1.96 for changes in abduction/ external rotation, and Z = 1.59, p < 1.96 for external rotation alone.

Dekker et al. (1997) reported that statistical analysis of the combined time series showed significant effects on pain (p=0.025). Analysis of the individual time series revealed that 5 out of the 7 patients had significant reduction of pain. ROM improved in four out of 7 patients but did not reach significance (p= 0.13). None of the secondary parameters showed significant changes.

Table 2. Characteristics of included studies examining joint protection in the hemiplegic arm

Study	Dean et al., 2000	Braus et al., 1994 (part 11)	Kumar et al., 1990
Design	RCT Control (n =13) Treatment (n=10)	Historical cohort Control (n=138) Treatment (n=83)	RCT ROM (n=12) skateboard (n=8) pulleys overhead (n=8)
Methods	Randomization and concealment appropriate. Outcome measures blinded.	Outcome measures blinded.	Randomization appropriate but not concealed. Outcome measure blinded.
Participants	CVA , n= 23; mean 58.1 yrs ; 1 center; clients score less than 5 on the Motor Assessment Scale; able to use visual analog scale	CVA, n=221; mean age 62.4 yrs; consecutive inpatients compared to previous series of 132 stroke survivors where the incidence of shoulder-hand-syndrome (SHS) was found to be 27%	CVA, n=28; mean age 64.9 yrs; 1 center; all subjects had infarcts confirmed by CT; no difference in degree of subluxation, time posts stroke or age between the 3 groups
Time post stroke (mean)	33.5 days	within two weeks (not specified)	14.5 days
Interventions	Effect of shoulder positioning on shoulder joint pain and range of motion vs. no prolonged positioning. Both groups received multi-disciplinary rehabilitation. Treatment group received prolonged positioning for 20 minutes for 5 days a week for 6 weeks	Effect of protective handling of the hemiplegic arm and hand on the prevention of trauma. All members of the therapeutic and diagnostic teams were provided with detailed instructions from the beginning of hospitalization to avoid injuries to the affected limb.	Effect of 3 different exercise programs on the occurrence of shoulder pain. Prescribed exercise program once a day for 10 minutes, about 20 repetitions, 5-days/ week while in hospital. All exercises supervised by an OT. Assessed once a month for 3 months. Length of interventions not specified.
Outcomes	Differences measured in VAS for pain, active and range of movement	Incidence of the diagnosis of SHS as defined by a set criteria	occurrence of shoulder pain
Notes	Small sample size; no follow-up 22% drop-out; 2 breaches of protocol; intention to treat analysis showed no difference between the two groups.	Similar to the control group in sex, age and cause of stroke	Intensity of pain not measured; incidence of pain documented at rest or during passive range of movement. No dropouts.
Critical appraisal rating	19/27	15/27	17/27

Summary of the evidence

In a prospective study, Braus et al. (1994) reported that the incidence of shoulder-hand syndrome developed in 36 (27%) of 132 stroke survivors. In a placebo- controlled, non-blinded trial, 31 of the 36 patients became almost symptom free within ten 10 days' treatment with low oral corticosteroids, Shoulder joint capsules, taken at autopsy of 7 patients, showed signs of previous trauma to the affected shoulder. In the second part of this study on another 86 patients, early awareness of potential injuries to the shoulder joint structures reduced the frequency of shoulder-hand syndrome from 27% to 8%.

Comparing the number of patients who developed pain in each exercise group, Kumar et al. (1990) found that there was a significant difference. The highest incidence of developing pain in the hemiplegic upper limb occurred with patients who were in the overhead pulley group (62%), followed by 12% of the patients who were in the skate board group; the lowest occurrence of pain (8%) was in the range of motion by the therapist group, p=0.014. Side of hemiplegia, degree of subluxation, or extent of impairment did not differ between the three groups.

In investigating the effect of a shoulder positioning protocol on shoulder joint pain and range of movement in the affected upper limb, Dean et al. (2002) found no difference between the groups.

Table 3. Characteristics of included studies examining the treatment of post-stroke hand edema and shoulder-hand syndrome

Study	Geurts et al., 2000	Gracies et al., 2000	Dirette and Hinojosa, 1994
Design	Systematic review on the etiology and treatment. Treatment studies: Faghri (1994); Giudice (1990) ; Braus (1994); Davis (1977); Hamamci (1996)	Case series, cross over (n =16)	single subject (ABA) (n= 2)
Methods	Studies were evaluated on 11 methodological criteria including a comprehensive search, study criteria, selection bias, studies' internal validity, intention-to-treat analysis, power, and effect sizes.	Outcome measure and subjects not blinded.	Outcome measure and subjects not blinded.
Participants	CVA with SHS including loss of ROM of abduction & external rotation with presence of pain; elbow free of signs; considerable pain on limited wrist extension with tenderness and edema over carpal bones; pain on limited MCP, PIP and DIP flexion; changes in hair, nail growth; changes in temperature, colour	CVA, n=16; mean age 65.2 yrs; inpatients and outpatients from 2 centers; had flexor and pronator spasticity in upper limb for more than 3 weeks	CVA, n= 2, mean age 68.5 years, had flaccid tone with, no voluntary movement, had moderate edema in hand
Time post stroke (mean)	15 weeks	11 weeks	4 weeks
Interventions	Faghri: NMS + hand elevation Guidice: CPM +elevation vs. arm elevation Braus: before & after 6 months of methy-prednisolene Braus: trauma prevention vs. no prevention Hamamci: calcitonin vs. placebo Davis: oral steroids s (case series)	Effect of individually tailored Lyrca garments on swelling, resting posture, active and passive ROM. Worn 3 hours 1 day, no intervention the next for only the two days	Effect of continuous passive movement machine (CPM) on hand edema. One week of baseline, 2 hours daily of CPM +regular OT/PT for second week, 3rd. week reassessment.
Outcomes	Faghri: hand volume Guidice: hand volume, passive finger ROM Braus: SHS score Hamamci: Pain, shoulder tenderness, MCP extension Davis: pain, joint mobility	Elbow & wrist resting posture; spasticity (Tardieu scale); comfort; AROM &PROM with goniometer; circumference of limb segment	Measured differences with hand volumeter and finger circumference (Jeweller's rings).
Notes	Minor flaws in the systematic review. (score of 5 out of 7 on the Oxman-Guyatt Index). Search methods were clearly identified. Three referees with consensus to eliminate selection bias. Clear criteria for SHS. Z scores calculated where possible. No mathematical conclusion to overall treatment effectiveness	Only 6 subjects had hand edema. No follow-up. Very short treatment time. Assessment except for swelling with garment. Measurements taken once.	Small sample size. Unclear whether there were other interventions to decrease swelling. Rings not sensitive to small changes in edema. Reliability of volumeter questionable.
Critical appraisal rating	5/7 Oxman Guyatt Index	N/A	N/A

Geurts et al., 2000

Table 3a. Standardized effect scores of main parameters

First author	Parameter	Z-score
Faghri (n =8)	NMS vs. elevation	**3.7**
Giudice (n=11)	CPM+elevation vs. elevation	**.77**
Braus (n=34)	before and after 6 month of methyl-prednisolone	**8.3**
Braus (n=218)	trauma prevention vs. no prevention: frequency of SHS score	**7.5**
Hamamci (n =41)	calcitonin vs. placebo : pain	**4.9**
	shoulder exorotation	**1.9**
	MCP extension	**1.3**
Davis* (n=68)	oral steroids	**N/A**

* inadequate methodology with poor control of causal and confounding factors (Geurts et al. , 2000)

Table 3b. Main clinical findings of therapeutic studies (Geurts et al., 2000)

First author	Outcome
Faghri	neuromuscular stimulation has a better short-term effect than limb elevation on post-stroke hand edema
Giudice	continuous passive motion with limb elevation has a better short-term effect than limb elevation alone on post- stroke hand edema
Braus	32 mg/day oral methylprednisolone tapering over 4 weeks has a good long term effect on reducing symptoms and signs of post- stroke SHS within 2 weeks as compared to placebo medication
Braus	trauma prevention may reduce frequency of post-stroke SHS from 27% - 8%
Hamamci	100 IU/day intramuscular calcitonin for 4 weeks is more effective than placebo treatment for reducing pain, tenderness, and improving joint mobility in post-stroke SHS within 4 weeks
Davis	16-mg/day oral triamcinolene diacetate tapering over 4 weeks gives almost complete and long-term relief of pain and improvement of mobility in post-stroke SHS within 4 weeks.

Summary of the evidence

Geurts et al., 2000

Based on their systematic review, these authors concluded that in 50% of cases involving painful hand and wrist edema, the shoulder was not involved. The shoulder-hand syndrome usually involved joint inflammations resulting from trauma, which coincided with increased arterial blood flow. Oral steroids were the most effective treatment for SHS.

Dirette, 1994
Visual analysis by graph showed that continuous passive motion decreased hand edema.

Gracies et al., 2000
During the 3 hours, garments worn reduced digit circumference by 4% ($p < 0.01$) and improved shoulder PROM by 4 degrees.
Treatment effect for hand edema (n=6) was significant, $Z= 2.94$, $p >1.96$.

Summary of meta-analysis

Combining the Z-scores for two studies (Faghri, Giudice) which looked at whether movement + elevation was more effective than elevation alone in reducing hand edema, the overall Z score was significant, Z= 3.2, p > 1.96.in favour of movement with elevation.

Table 4. Characteristics of included studies examining the effectiveness of strapping the hemiplegic shoulder

Study	Hanger et al., 2000	Ancliffe, 1992	Morin and Bravo, 1997
Design	RCT Control (n =49) Treatment (n= 49)	Cohort Control (n =4) Treatment (n= 4)	Case series (n= 15)
Methods	Randomization and concealment was appropriate. Subjects were blinded but it is not clear if the outcome measures were blinded. Stratification according to baseline disability prior to randomization	Outcome measures not blinded; pilot study; alternate allocation to group	Assessors were blinded.
Participants	CVA, n=98; mean age 78.4 yrs; 1 center; inpatients; had weakness in shoulder abduction	CVA, n=8; mean age 71.8 yrs; 1 center; no history of shoulder pain; no voluntary movement in arm	CVA, n=15; mean age 65.3; 1 center; had shoulder subluxation present
Time post stroke (mean)	15.2 days	within 48 hours of admission	71.2 days
Interventions	Effect of strapping of hemiplegic shoulder vs. no strapping. Both groups received inter-disciplinary treatment based on task-specific reeducation; treatment group had strapping for total or 6 weeks or if they could abduct shoulder to 90°vs. gravity or discharged. Strapping remained on for 2-3 days and replaced by PT.	Effect of strapping the hemiplegic shoulder vs. no strapping. Strapping changed every 3-4 days. Applied by PT.	Effect of conventional sling, strapping or combination of sling + strapping on degree of shoulder subluxation; baseline x-ray with no adjuncts; strapping and sling applied and x-rayed; 5 days later x-rayed sequentially with strapping + sling, only sling, only strapping. No other intervention. Total length of study 5 days
Outcomes	Differences measured in shoulder pain (VAS), active range of movement, Rankin, FIM, and Motor Assessment Scale (MAS)	Differences measured in presence of pain with the Ritchie Articular Index	Differences measured in degree of subluxation with x-ray
Notes	Follow-up at 6 (n =83) and 14 weeks (n=73); eligibility criteria not specified; 5 % initial drop-outs; intention-to-treat analysis showed no significant difference; groups matched except treatment group had 25% more subjects with hemorrhages; 6.1% of clients had adverse effect of skin irritation.	No follow-up; small sample size; unclear as to whether there was additional treatment during study; no adverse effects reported; unclear as to length of study; rate of motor recovery not reported; confounders discussed; severity of pain not assessed; strapping may prompt more careful handling by nurses	Follow-up 3 days later; small sample size; 21% drop-out; 7 aphasic subjects were excluded because of inability to reduce subluxation; sample size calculated with sufficient power with n of 15; reliability of positioning shoulder and degree of subluxation an issue; no control for motor recovery.
Critical appraisal rating	23/27	14/27	N/A

Summary of the evidence

Ancliffe (1992) reported that the strapping group experienced a significantly longer pain-free period (mean = 21 days) compared to the non-strapping group (mean =5.5 days), Z = 6.17. On the other hand, Hanger et al., 2000 reported no significant difference in the presence of pain (p =0.09, Z = 1.03), the range of movement, and functional outcomes (p=0.12) at the end of the intervention phase or at final assessment.

Hanger et al. (2000) reported that the intention -to-treat analysis showed no significant difference in pain, range of movement, or functional outcomes after the intervention phase or at final assessment. However, there were trends for less pain at 6 weeks (VAS, p =0.11) and better upper limb function (MAS, p=0.16) in strapped patients.

Morin and Bravo, 1997. Inadequate methodology. No significant or clinical results.

Summary of meta-analysis

Combining the results from the two studies with controls (Hanger et al., 2000 and Ancliffe, 1992), there was a significant Z for a decrease of pain in hemiplegic shoulders with the use of strapping, Z =6.11, p > 1.96. However, strapping did not prevent the onset of pain. Of clinical significance was the early mean loss of passive range of external rotation reported by Hanger et al., 2000. The mean loss of external rotation was 45.9°(95% CI 38.0 -53.8), which equated to a decline of external rotation of 2.5°(95% CI 2.1 - 2.0) per week. Shoulder strapping did not alter the rate at which range of external rotation of the hemiplegic shoulder was lost. There was no evidence that strapping reduced subluxation.

Table 5. Characteristics of included studies examining the effectiveness of supportive devices to decrease shoulder subluxation in stroke survivors

Study	Hurd et al., 1974	Moodie et al., 1986	Williams et al., 1988	Zorowitz et al., 1995
Design	Cohort Control (n =7) Treatment (n=17)	Case series (n = 10)	Case series (n = 26)	Case series (n=20)
Methods	Outcome measures not blinded. Subjects alternatively assigned to groups.	Outcome measures not blinded.	Repeated measures. Outcome measure not blinded.	Repeated measures. Outcome measures blinded.
Participants	CVA, n= 14; range 22-87 yrs (no mean); 1 center; had frail upper extremity; had no history of trauma to neck, arm or shoulder	CVA, n=10; mean age 57.5 yrs; inpatient and outpatient; exhibited clinical evidence of shoulder subluxation by palpitation	CVA, n=26; mean age 66.1 yrs; 1 center; had Brunnstrum arm staging 3 or less (n=22), greater than 3(n=4); G-H subluxation	CVA, n=20; mean age 63 years; 1 center; 65% non-hemorrhagic strokes; 40% Brunnstrum Stage 2, 55% Stage 3, 5% Stage 4.
Time post stroke (mean)	acute (no data provided)	28 days (median) range 14-1795	64.9 days	within 6 weeks (not described)
Interventions	Effect of hemisling vs. no sling. No description of protocol except for giving sling. Patients treated identically in all other respects but not described.	Effect of 5 support devices (conventional triangular sling, Bobath shoulder roll, Hook-Hemi Harness, plexiglass lap tray, arm trough) on shoulder subluxation. Applied sequentially in same order, with a total of 7 x-rays taken. No other intervention .	Effect of Bobath shoulder roll and the Henderson shoulder ring on shoulder subluxation. Applied sequentially in same order. No other intervention.	Effect of 4 different support devices (hemisling, Bobath shoulder roll, Rolyan humeral cuff sling, Cavalier support) on shoulder subluxation. Applied in same order. No order treatment intervention.
Outcomes	Differences measured in range of movement (not described) and EMG (not quantified)	Differences measured in the degree of subluxation by x-ray	Differences measured in the degree of subluxation by x-ray	Differences measured in the degree of subluxation by x-ray
Notes	Small sample size; follow-up at 3 months (n=9); 36% drop-out; methods not described; pain in treatment group (86% vs. control (29%). No control of amount of therapy given to the two groups. No description of group characteristics.	No follow-up; small sample size; possible order effect; low inter-rater reliability for the study	No follow-up; small sample calculated; Test-retest reliability of rater high (r=0.99).	Screened 219 with 26% eligible (6 drop-outs); no follow-up; small sample size; possible order effect; no test-retest reliability of rater reported. Order of x-rays randomized.
Critical appraisal rating	9/27	N/A	N/A	N/A

Summary of the evidence

Hurd et al. (1974) concluded that there was no appreciable difference between the treated or control groups using the parameters of shoulder range of motion, shoulder pain, subluxation.

Moodie et al. (1986) reported that the conventional sling reduced subluxation in 8 out of 10 subjects, the arm trough reduced subluxation 6 out of 10 clients, and the lap tray reduced subluxation in 7 out of 10 subjects ($p < 0.001$). There was very little difference between the three supports. The Hook Hemi Harness and the Bobath shoulder roll tended to under-correct subluxation and that neither aid could reduce the degree of subluxation to within 0.5 cm. of the normal control (unaffected side).

Williams et al. (1988) reported that both the Bobath shoulder roll and the Henderson shoulder ring both reduced shoulder subluxation ($p < 0.001$). However, the authors did not find a significant difference between the two types of support in decreasing shoulder subluxation. However, the subjects reported more comfort with the Henderson shoulder ring.

Zorowitz et al. (1995) reported that the hemisling eliminated the vertical asymmetry of subluxation over the entire study group, but each support (hemisling, Bobath roll, Rolyan, Cavalier) corrected the vertical asymmetry best in some subjects (55%, 20%, 40% and 5% respectively). The Bobath roll and the Cavalier support produced lateral displacements of the humeral head of the affected shoulder ($p= 0.005$, 0.004 respectively). The Rolyan humeral cuff sling reduced total subluxation asymmetry ($p=0.008$) whereas the hemisling, Bobath roll or the Cavalier support did not alter total asymmetry ($p= 0.091$) 0.283, 0.502 respectively.

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