Chapter 11

EBRSR

HEMIPLEGIC SHOULDER PAIN AND COMPLEX REGIONAL PAIN SYNDROME

HEART & STROKE FOUNDATION
Canadian Partnership for Stroke Recovery

Marcus Saikaley, BSc
Jerome Iruthayarajah, MSc
Griffin Pauli, MSc,
Alice Iliescu, BSc
Joshua Wiener, MSc Candidate
Andreea Cotoi, MSc
Niko Fragis, BSc Candidate
Ricardo Viana, MD
John Chae, MD
Richard Wilson, MD
Tom Miller, MD
Robert Teasell, MD

Chapter 11: Hemiplegic shoulder pain and complex regional pain syndrome Table of contents

Key points

Management of Hemiplegic Shoulder

Factors associated with hemiplegic shoulder pain include older age, longer disease duration, poor arm function, muscle imbalance, rotator cuff tear, subscapularis/pectoralis spasticity, glenohumeral subluxation, bursitis, tendonitis, adhesive capsulitis, and complex regional pain syndrome.

Shoulder subluxation may occur early on in the hemiplegic arm due to flaccid supporting shoulder musculature and can be exacerbated by external forces and is associated with pain.

Shoulder sustained positioning or range of motion exercise may not be beneficial for shoulder hemiplegia following stroke.

A functional orthosis may be beneficial for shoulder hemiplegia following stroke.

Slings are likely not beneficial for shoulder hemiplegia following stroke.

Shoulder taping may be effective for improving following stroke.

The literature is mixed regarding shoulder taping's benefit for improving range of motion

Shoulder taping may not be effective for improving motor function, spasticity, or activities of daily living following stroke.

Robotics may be beneficial for improving range of motion, pain and activities of daily living in a hemiplegic shoulder.

Thermal stimulation may not be beneficial for reducing pain in shoulder hemiplegia following stroke.

Extracorporeal shockwave therapy may be beneficial for improving pain, but not motor function in shoulder hemiplegia following stroke.

Interferential current therapy may be more beneficial than sham therapy for improving shoulder hemiplegia after stroke.

The literature is mixed regarding cyclic neuromuscular electrical stimulation for shoulder hemiplegia following stroke.

Intramuscular or electromyographic-triggered neuromuscular electrical stimulation for shoulder hemiplegia may be beneficial for improving pain, but not other outcomes following stroke.

The literature is mixed regarding functional electrical stimulation for shoulder hemiplegia following stroke.

The literature is mixed regarding high voltage pulsed galvanic stimulation for shoulder hemiplegia following stroke.

Repetitive transcranial magnetic stimulation is likely beneficial for reducing pain in shoulder hemiplegia, but not for improving motor function, range of motion, or muscle strength post stroke.

The literature is mixed regarding non-invasive transcutaneous electrical nerve stimulation and invasive peripheral nerve stimulation for shoulder

Botulinum toxin A may not be beneficial for improving shoulder hemiplegia after stroke.

The literature is mixed regarding the effectiveness of triamcinolone acetonide alone or in combination with transcutaneous electrical stimulation for shoulder hemiplegia following stroke.

The literature is mixed regarding the effectiveness of hyaluronic acid injections for reducing hemiplegic shoulder pain, while hyaluronic acid injections are likely not effective for improving motor function, range of motion, or spasticity in the hemiplegic shoulder following stroke.

The literature is mixed regarding the effectiveness of suprascapular nerve block for reducing hemiplegic shoulder pain, while suprascapular nerve block is likely not beneficial for improving motor function, range of motion, or activities of daily living following stroke.

Segmental neuromyotherapy is likely beneficial for improving motor function, and possibly hemiplegic shoulder pain, but likely not beneficial for improving spasticity following stroke.

Acupuncture may beneficial for improving pain in the hemiplegic shoulder after stroke.

Acupressure and massage therapy are likely beneficial for motor function and hemiplegic shoulder pain following stroke.

Management of Complex Regional Pain Syndrome

Peripheral changes due to complex regional pain syndrome include pain, edema, dystrophy, immobility, and vasomotor instability of the affected upper limb.

Central changes due to complex regional pain syndrome include sensory cortical processing, motor cortex disinhibition, and disrupted body schema.

Steroids are likely beneficial for improving motor function and pain following a stroke.

Steroids may not be beneficial for improving activities of daily living.

Ultrasound guided injection for nerve block agents may not be beneficial for improving complex regional pain syndrome.

Mirror therapy may be beneficial for improving motor function, pain and activities of daily living in individuals affected by complex regional pain syndrome but may not be beneficial for improving spasticity.

Mental practice may be beneficial for reducing pain in individuals with complex regional pain syndrome.

Aerobic exercise is likely beneficial for improving pain but may not be effective for improving activities of daily living following stroke.

Modified Sackett Scale

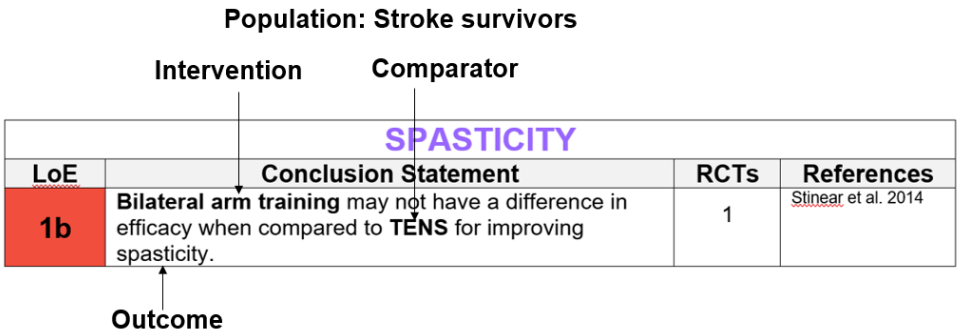
Level of evidence	Study design	Description
Level 1a	Randomized controlled trial (RCT)	More than 1 higher quality RCT (PEDro score ≥6).
Level 1b	RCT	1 higher quality RCT (PEDro score ≥6).
Level 2	RCT	Lower quality RCT (PEDro score <6).
	Prospective controlled trial (PCT)	PCT (not randomized).
	Cohort	Prospective longitudinal study using at least 2 similar groups with one exposed to a particular condition.
Level 3	Case Control	A retrospective study comparing conditions, including historical cohorts.
Level 4	Pre-Post	A prospective trial with a baseline measure, intervention, and a post-test using a single group of subjects.
	Post-test	A prospective post-test with two or more groups (intervention followed by post-test and no re-test or baseline measurement) using a single group of subjects
	Case Series	A retrospective study usually collecting variables from a chart review.
Level 5	Observational	Study using cross-sectional analysis to interpret relations. Expert opinion without explicit critical appraisal, or based on physiology, biomechanics or "first principles".
	Case Report	Pre-post or case series involving one subject.

New to the 19th Edition of the Evidence-based Review of Stroke Rehabilitation

1) PICO Conclusion Statements

This edition of Chapter 11: Hemiplegic Shoulder Pain and Complex Regional Pain Syndrome synthesizes study results from only randomized controlled trials (RCTs), all levels of evidence (LoE) and conclusion statements are now presented in the Population Intervention Comparator Outcome (PICO) format.

For example:

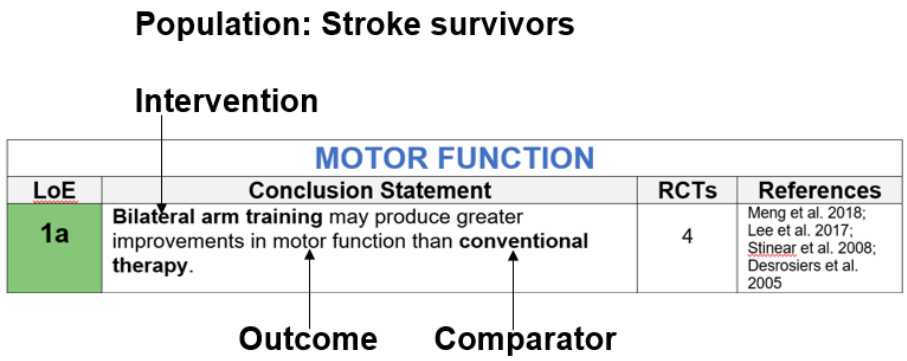


New to these statements is also the use of colours where the levels of evidence are written.

Red statements like above, indicate that the majority of study results when grouped together show no significant differences between intervention and comparator groups.

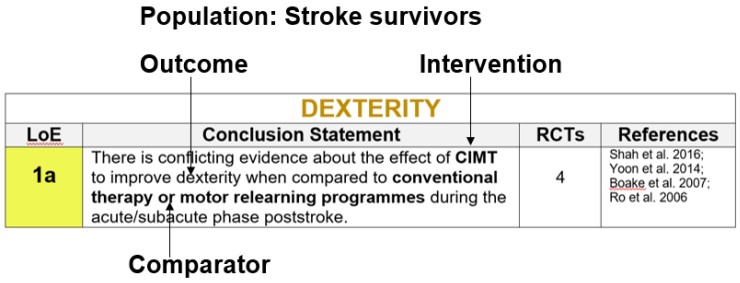
Green statements indicate that the majority of study results when grouped together show a significant between group difference in favour of the intervention group.

For example:



Yellow statements indicate that the study results when grouped together are mixed or conflicting, some studies show benefit in favour of the intervention group, while others show no difference between groups.

For example:



DEXTERITY			
LoE	Conclusion Statement	RCTs	References
1a	There is conflicting evidence about the effect of **CIMT** to improve dexterity when compared to **conventional therapy or motor relearning programmes** during the acute/subacute phase poststroke.	4	Shah et al. 2016; Yoon et al. 2014; Boake et al. 2007; Ro et al. 2006

2) Shoulder Rehabilitation Outcome Measures

Outcome measures were classified into the following broad categories:

Motor function: These outcome measures covered gross motor movements and a series of general impairment measures when using the upper extremities.

Activities of daily living: These outcome measures assessed performance and level of independence in various everyday tasks.

Spasticity: These outcome measures assessed changes in muscle tone, stiffness, and contractures.

Range of motion: These outcome measures assessed a patient's ability to freely move their upper extremity through flexion, abduction, and subluxation movements for instance, both passively and actively.

Stroke severity: These outcome measures assessed the severity of one's stroke through a global assessment of a multitude of deficits a stroke survivor may experience.

Muscle strength: These outcome measures assessed muscle power and strength during movements and tasks.

Pain: These outcome measures assessed the presence and management of hemiplegic shoulder pain.

Outcome measures that fit these categories are described in the next few pages.

Outcome measures definitions

Motor Function

Action research arm test: Is a measure of activity limitation in the paretic arm that assesses a patient's ability to handle objects differing in size, weight and shape. The test evaluates 19 tests of arm motor function, both distally and proximally. Each test is given an ordinal score of 0, 1, 2, or 3, with higher values indicating better arm motor status. The total ARAT score is the sum of the 19 tests, and thus the maximum score is 57. This measure has been shown to have good test-retest reliability and internal validity when used to assess motor function in chronic stroke patients (Ward et al. 2019; Nomikos et al. 2018).

Brunnstrom motor recovery stages: Is a measure of motor function and muscle spasticity in stroke survivors. The measure contains 35 functional movements which are done with the guidance of a clinician (e.g. should abduction, shoulder adduction, leg flexion/extension). These movements are evenly divided into 2 sections: upper extremity and lower extremity. Each movement is then rated on a 6-point scale (1=Flaccidity is present, and no movements of the limbs can be initiated, 2=Movement occurs haltingly and spasticity begins to develop, 3=Movement is almost impossible and spasticity is severe, 4=Movement starts to be regained and spasticity begins to decline, 5=More difficult movement combinations are possible as spasticity declines further. 6=Spasticity disappears, and individual joint movements become possible). This measure has been shown to have good reliability and concurrent validity (Naghdi et al. 2010; Safaz et al. 2009).

Constant-Murley Scale: Is a measure of shoulder joint function that assesses pain intensity (15 points), mobility of shoulder joint measured via range of motion (20 points), activities of daily living (40 points), and muscle power (25 points). The total score adds up to be a number out of 100, where a higher score indicates greater shoulder joint function. The measure is shown to have sufficient construct and longitudinal validity; however, its reliability varies in the literature (Kim & Kwak 2016; Kim et al. 2016; Mahabier et al. 2017; Roy et al. 2010).

Croft disability index: Is a 22-item questionnaire that evaluates shoulder disability. The measure consists of 22 items which can be answered "yes" or "no", and positive responses are summed to give a score. A higher score indicates severe disability, with 22 being the highest score possible. The measure has demonstrated adequate construct validity (Stergioulas 2008; Staples et al. 2010).

Fugl-Meyer Assessment: Is an impairment measure used to assess locomotor function and control of the upper and lower extremities, including balance, sensation, and joint pain in patients poststroke. It consists of 155 items, with each item rated on a three-point ordinal scale. The maximum motor performance score is 66 points for the upper extremity section, 34 points for the lower extremity section, 14 points for the

balance section, 24 points for sensation section, and 44 points each for passive joint motion and joint pain section, for a maximum of 266 points that can be attained. The upper extremity section consists of four categories (Shoulder/Elbow/Forearm, Wrist, Hand/Finger, and Coordination) and includes 23 different movements which evaluate 33 items. The items are scored on a 3-point rating scale: 0=unable to perform, 1=partial ability to perform and 2=near normal ability to perform. The measure is shown to have www.ebrsr.com Page 12 good reliability and construct validity (Okuyama et al. 2018; Villan-Villan et al. 2018; Nilsson et al. 2001; Sanford et al. 1993).

Modified Brunnstrom classification: Is a measure of motor function in which patient motor function is evaluated and graded based on 6 stages: 1-unable to move fingers voluntarily, 2-able to move fingers voluntarily, 3-able to close hand voluntarily; unable to open hand, 4-able to grasp a card between thumb & radial side of index finger; able to extend fingers slightly, 5-able to pick up & hold a glass; able to extend fingers fully, 6-able to catch & throw a ball in a near-normal fashion; able to button & unbutton a shirt. Higher stages indicate greater motor functioning. This classification is a shortened form of the Brunnstrom recovery stages, designed to make assessment quicker to administer, and its reliability and validity are well established (Jang et al. 2012).

Shoulder disability questionnaire: Is a measure of shoulder disability that consists of 22 self-reporting items to which participants respond with either yes or no. The score ranges from 0 to 22, with a higher score indicating a greater degree of disability. The measure has strong associations with quality of life measures and has proven levels of validity in stroke patients (Rah et al. 2012).

Wolf motor function test: Is a measure that quantifies upper extremity motor ability in stroke survivors. The measure consists of 17 tasks (e.g. lifting arm up using only shoulder abduction, picking up a pencil, picking up a paperclip). These tasks are then subdivided into 3 areas: functional tasks, measures of strength, and quality of movement. Patients are scored on a 6-point scale (1=cannot complete task, 6=completes task as well as the unaffected side. This measure has been shown to have good reliability and validity (Wolf et al. 2005; Wolf et al. 2001).

Activities of Daily Living

Arm motor ability test: Is a measure of upper extremity limitation for stroke survivors in performing activities of daily living. The measure consists of 13 common unilateral and bilateral tasks (e.g. manipulating objects such as utensil and telephones; donning/doffing a piece of clothing). Each task is scored on two, 6-point ordinal scales assessing functional ability and the quality of the movement performed. The measure has been shown to have good reliability and construct validity, in its full form and in abbreviated versions for stroke survivors (Fulk et al. 2017; O'Dell 2013; O'Dell 2011).

Barthel index: Is a measure of how well a stroke survivor can function independently and how well they can perform activities of daily living (ADL). There is a modified version of the scale which assesses the same things but is a shortened version of the full scale. Both forms of the measure consist of a 10-item scale (e.g. feeding, grooming, dressing, bowel control). Possible total scores for the full form range from 0 to 100, while the shortened form scores range from 0 to 20. This measure has been shown to have good reliability and validity in its full form (Gonzalez et al. 2018; Park et al. 2018).

Frenchay arm test: Is a measure of upper extremity motor control that a stroke survivor possesses. The measure consists of 5 common tasks that require use of the upper extremity (e.g. stabilize a ruler/draw a line with a pencil, comb hair, clip a clothespin onto the edge of a table, grasp a cylinder, drink from a glass of water and then set it down). Each task is then scored on a 2-point scale wherein each task receives either a 0 (unsuccessful completion) or a 1 (successful completion). This measure has been shown to have good reliability and validity in its full form. (Heller et al. 1987; Parker et al. 1986).

Functional independence measure: Is an 18-item outcome measure composed of both cognitive (5-items) and motor (13-items) subscales. Each item assesses the level of assistance required to complete an activity of daily living on a 7-point scale. The summation of all the item scores ranges from 18 to 126, with higher scores being indicative of greater functional independence. This measure has been shown to have excellent reliability and concurrent validity in its full form (Granger et al. 1998, Linacre et al. 1994; Granger et al. 1993).

Modified Barthel Index (MBI): Is a measure of how well a stroke survivor can function independently and how well they can perform activities of daily living (ADL). The measure consists of a 10-item scale (e.g. feeding, grooming, dressing, bowel control). Possible scores range from 0 to 20. This measure has been shown to have good reliability and validity in its full form. (MacIsaac et al. 2017; Ohura et al. 2017).

Motor activity log: Is a patient-reported measure of the use and quality of movement of the impaired arm. The measure consists of 30 functional tasks (e.g. handling utensils, buttoning a shirt, combing hair). Each task is then measured on a 6- point scale

(0=complete inability to use affected arm). This measure has been shown to have good reliability and validity (Chuang et al. 2017).

Motor assessment scale: Is a performance-based measure that assesses everyday motor function. The measure consists of 8 motor-function based tasks (e.g. supine lying, balanced sitting, walking). Each task is then measured on a 7-point scale (0=suboptimal motor performance, 6=optimal motor performance). This measure has been shown to have good reliability and concurrent validity (Simondson et al. 2003).

Spasticity

Modified Ashworth Scale (MAS): Is a measure of muscle spasticity for stroke survivors. The measure contains 20 functional movements which are done with the guidance of a trained clinician. These movements are evenly divided into 2 sections: upper extremity and lower extremity. Each movement is then rated on a 6-point scale (0=no increase in muscle tone, 1=barely discernible increase in muscle tone 1+=slight increase in muscle tone, 2=moderate increase in muscle tone 3=profound increase in muscle tone (movement of affected limb is difficult) 4=complete limb flexion/rigidity (nearly impossible to move affected limb)). This measure has been shown to have good reliability and validity (Merholz et al. 2005; Blackburn et al. 2002).

Range of Motion

Aromio-humeral distance: Is a measure of the subacromial space, measured as the linear distance from the humeral head to the acromial tip. Acromio-humeral distance varies with shoulder position, thus is often measured with the patient's arm in a neutral position by their side. AHD has been measured using X-ray, MRI, computed tomography, and ultrasonography. Ultrasound measures have high validity and good intra- and inter-rater reliability (Klich et al. 2019; Sealey & Critchley 2017).

Active shoulder flexion: Is a measure of shoulder range of motion assessed using goniometric measurement while the patient is in a supine or seated position. It may be measured as the angle between the humerus and thorax. This method has previously been found to have excellent reliability and validity (Chatterjee et al. 2016; Mueller et al. 2018; Bullock et al. 2005).

Passive range of motion: Is a measure of the range of motion stroke survivors possess while receiving assistance. Contrary to active range of motion, which measures range of motion without receiving assistance and consists of 20 movements, passive ROM consists of 30 functional movements for both the upper and lower extremity. The movements are evenly divided into 2 sections: upper extremity and lower extremity. These movements are then rated on a 5-point ordinal scale (0=cannot complete movement, 4=completes movement as well as the unaffected side). This measure has been shown to have good test/retest reliability and validity (Lynch et al. 2005).

Stroke Severity

Modified Rankin Scale (MRS): Is a measure of functional independence for stroke survivors. The measure contains 1 item. This item is an interview that lasts approximately 30-45 minutes and is done by a trained clinician. The clinician asks the patient questions about their overall health, their ease in carrying out ADLs (cooking, eating, dressing) and other factors about their life. At the end of the interview the patient is assessed on a 6-point scale (0=bedridden, needs assistance with basic ADLs, 5=functioning at the same level as prior to stroke). This measure has been shown to have good reliability and validity (Quinn et al. 2009; Wilson et al. 2002).

Muscle Strength

Motricity index: Is a measure of motor function involving strength testing of six muscle actions. The muscle actions are graded and assigned weighted scores based on movement present and resistance taken. Weighted scores for each action are then added to obtain scores for each of the three subscales of the measure (arm, leg, and trunk). Each section is scored from 0 to 100, where 0 indicates complete motor function loss. The measure is found to be reliable and valid for use with stroke patients (Safaz et al. 2009; Cameron & Bohannon 2000).

Muscle thickness: Is defined as the distance between two fascias and is highly correlated to the cross-sectional area of a muscle, the strength of the muscle, and its resistance to fatigue. Measurements of muscle thickness from various anatomical sites can be combined with height to make accurate predictions of whole-body muscle mass and body composition in patients. The most widely used ways to assess muscle thickness in stroke patients are using computed tomography, magnetic resonance imaging, and ultrasound (Strasser et al. 2013; Schimmel et al. 2010; English et al. 2012).

Pain

Brief pain inventory: Is a self-administered questionnaire designed to measure pain intensity and the extent to which pain interferes in the lives of pain sufferers. There is a short (9 items) and a long (17 items) form of the questionnaire, however the short form is more frequently used. The short form is composed of pain drawing diagrams, four items about pain intensity (requires patients to rate their worst, least, average, and current pain intensity), two items on pain relief treatment or medication, and one item on pain interference. Pain interference requires patients to rate, on a scale of 0 to 10, the degree to which pain interferes with 7 domains of functioning (general activity, mood, walking ability, normal work, relations with other persons, sleep, and enjoyment of life). The measure gives 2 main scores: a pain severity score (calculated from the 4 items on pain intensity) and a pain interference score. The pain drawing diagrams and pain relief treatment to not contribute to scoring. The measure shows good test-retest reliability for malignant and non-malignant pain intensity and interference (Poquet & Lin 2016; Tan et al. 2004).

Complex regional pain syndrome scale: Is a measure of the severity of complex regional pain syndrome (CRPS) assessed on a 0-14 scale including 4 domains. The 4 domains included are pain, edema, abduction, and external rotation of the shoulder joint (Kalita et al. 2016).

Lattinen Index: Is a measure of (usually chronic) pain that consists of five different dimensions; pain intensity, pain frequency, analgesic consumption, functional ability and hours of sleep. Each dimension is scored from 0-4, with the total score comprising of the sum of each section. This has been shown to have good reliability and validity (González-Escalada et al. 2012).

Numeric pain rating scale: Is an 11-point scale used for screening pain in many health care environments. In stroke settings, affected limbs of patients are typically stretched in a standardized manner, and pain is assessed on a scale of 0 (no pain) to 10 (worst possible pain). The number indicated by the patient is the pan intensity score. The scale is shown to have good validity in pain assessment of stroke patients (Krebs et al. 2007; Wissel et al. 2016; de Vries et al. 2017).

Penn shoulder score: Is a self-reported measure of shoulder pain that consists of 3 subscales including pain, satisfaction, and function. The 100-point scale consists of 30 points awarded to pain (3 items rated from 0 to 10, where a total score of 30=complete absence of pain), 10 points awarded to satisfaction (where 10=very satisfied with current level of function of shoulder), and 60 points awarded to function (where 60=all activities can be performed without difficulty). The total maximum score of 100 thus indicates high function, low pain, and high satisfaction with the function of the shoulder. The measure can be used in the aggregate, or each subscale can be used individually.

The measure is demonstrated to be valid and reliable for patients with various shoulder disorders (Leggin et al. 2006).

Shoulder-hand syndrome score: Is a measure of the presence or severity of clinical symptoms of shoulder hand syndrome in patients following stroke. It may be used to track effectiveness of subluxation treatment in reducing or preventing shoulder hand syndrome post-stroke. Sub-scores for sensation/pain, edema, and painless passive ROM in humeral abduction and external rotation are summed to give the total score. Currently, information on the measure's psychometric properties is very limited (Hartwig et al. 2012; Li et al. 2012).

Shoulder pain and disability index: Is a 13-item questionnaire that consists of 2 subscales that assess pain (5 items) and disability (8 items). The score is determined by taking an average of the 2 subscales, and scores can range from 0 to 100, with a higher score indicating greater pain and disability. The measure is shown to have good reliability; however, the construct validity varies by subscale. It is recommended to treat the two subscales separately, as the pain subscale has shown good construct validity, but the disability subscale has not (Pandian et al. 2013; Jerosch-Herold et al. 2018; Breckenridge & McAuley 2011).

ShoulderQ: is a questionnaire with both visual graphic rating scales, and verbal questions that is designed to asses the timing and severity of hemiplegic shoulder pain. This test is a sensitive and reliable measure for assaying shoulder pain.

Visual analogue scale: Is a self-report measurement scale used to measure mood, pain, and health-status of patients after stroke, especially for patients with aphasia or cognitive impairment. It typically consists of a 10-cm line anchored at either end by an extreme statement concerning the dimension that is being measured. Individuals are asked to make a mark on the line to reflect their current state between the 2 extremes, and then the position of their mark is measured in millimeters from the lower end. The measure has shown strong content validity in post-stroke populations, however there is limited positive evidence for its reliability and criterion validity (Price et al. 1999; de Vries et al. 2017).

Hemiplegic Shoulder Pain

Shoulder pain resulting from hemiplegia is a common clinical consequence of stroke and can result in significant disability (Najenson et al. 1971; Poduri, 1993). The pathogenesis of hemiplegic shoulder pain (HSP) is multifactorial and includes neurological and mechanical factors, often in combination, which vary among individuals post stroke.

Factors most frequently associated with HSP are glenohumeral subluxation, adhesive capsulitis, and spasticity, particularly of the subscapularis and pectoralis muscles (Grossens-Sills & Schenkman, 1985; Moskowitz et al. 1969). Suggested causes of HSP include complex regional pain syndrome, or injury to the rotator cuff musculotendinous unit (Chu et al. 1981; Nepomuceno & Miller, 1974).

Multivariable analyses have determined significant factors associated with an increased risk of developing HSP: age greater than 70, poor arm motor function, supraspinatus tendon tear/tendinosis, biceps tendon effusion, and adhesive capsulitis (Kim et al. 2014). Similarly, HSP has been found to be associated with longer disease duration and poor arm motor function (Karaahmet et al. 2014). Rajaratnam et al. (2007) identified three factors that predict the development of HSP in acute stroke with 98% accuracy: (1) a positive Neer test; (2) shoulder pain during the hand behind the neck manoeuvre; and (3) a difference of greater than 10° of passive external rotation at the shoulder joint.

Shoulder Subluxation and Hemiplegic Shoulder Pain

Pathophysiology

Shoulder subluxation is best defined as changes in the mechanical integrity of the glenohumeral joint that results in an incomplete dislocation, where articulating surfaces of the glenoid fossa and humeral head remain in contact. The glenohumeral joint is multiaxial and has a range of motion exceeding that of other joints in the body. In order to achieve this mobility, the glenohumeral joint must sacrifice stability. Stability is achieved through the rotator cuff, a musculotendinous sleeve that maintains the humeral head in the glenoid fossa, while at the same time allowing shoulder mobility. During the initial period following a stroke the hemiplegic arm is flaccid or hypotonic. Therefore, the shoulder musculature, in particular the rotator cuff musculotendinous sleeve, cannot perform its function of maintaining the humeral head in the glenoid fossa and there is a high risk of shoulder subluxation (Figure 1).

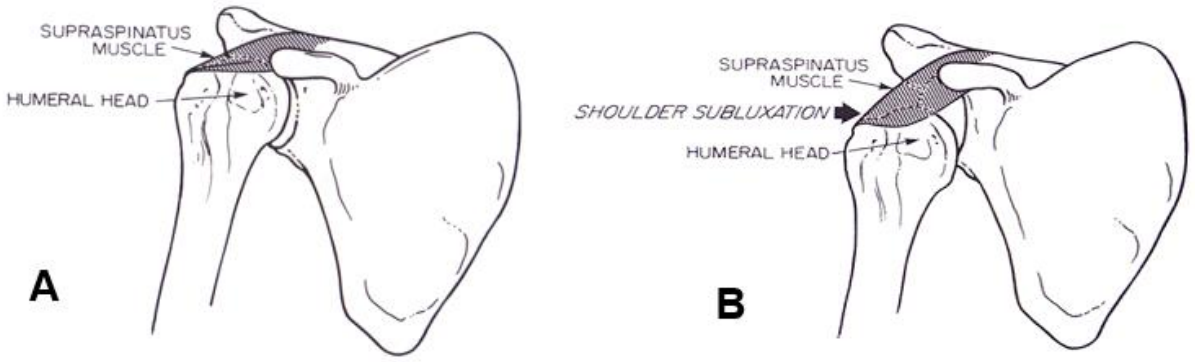


Figure 1a. Normal shoulder: *The humeral head is maintained in the glenoid fossa by the supraspinatus muscle.* **1b. Shoulder Subluxation***: The supraspinatus muscle is flaccid during the initial phase of hemiplegia. The weight of the unsupported arm can cause the humeral head to sublux downward in the glenoid fossa.*

Shoulder subluxation is a common problem in individuals with hemiplegia post stroke. During the initial flaccid stage of hemiplegia, the involved extremity must be adequately supported, or the weight of the arm will result in shoulder subluxation. Improper positioning in bed, lack of support in the upright position, and pulling on the hemiplegic arm during transfers all contribute to glenohumeral subluxation. Inferior subluxation commonly occurs secondary to prolonged downward pull on the arm, against which hypotonic muscles offer little resistance (Chaco & Wolf, 1971). The resulting mechanical effect is overstretching of the glenohumeral capsule, especially its superior aspect, and flaccid supraspinatus and deltoid muscles (Basmajian & Bazant, 1959; Shahani et al. 1981).

Pain in shoulder subluxation

It has long been assumed that if shoulder subluxation is not corrected, a pattern of traction on the flaccid shoulder will result in pain, decreased range of motion, and contracture (Grossens-Sills & Schenkman, 1985; Moskowitz, 1969; Roy et al. 1994; Savage & Robertson, 1982; Shai et al. 1984). However, it remains controversial as to whether it causes HSP (Bender & McKenna, 2001; Fitzgerald-Finch & Gibson, 1975; Moskowitz et al. 1969; Shahani et al. 1981). While some observational studies have reported a significant correlation between subluxation and pain in the hemiplegic shoulder (Aras et al. 2004; Lin et al. 2014; Lo et al. 2003; Paci et al. 2007; Suethanapornkul et al. 2008), several others failed to find such a relationship (Barlak et al. 2009; Bohannon, 1988; Bohannon & Andrews, 1990; Ikai et al. 1998; Joynt, 1992; Lin et al. 2014; Mohamed et al. 2014; Van Langenberghe & Hogan, 1988; Wanklyn et al. 1996; Zorowitz et al. 1996).

To be sure, patients with shoulder subluxation may not have HSP and patients with HSP may not have shoulder subluxation. The failure to consistently report an association may be due in part to a failure to examine the contribution of other probable etiological factors occurring concurrently. Paci et al. (2005) suggested that pain associated with subluxation likely presents later after stroke as “fibrous changes or injury can occur in connective tissue of the ligaments and joint capsule due to incorrect alignment between the humerus and the scapula”. As well, the lack of consistency among findings may be related to the heterogeneity of patient characteristics and method/timing of assessment.

Spasticity, Contractures and Hemiplegic Shoulder Pain

Pathophysiology

Spasticity is defined as a disorder of motor function characterized by a velocity-dependent increase in resistance to passive stretch of muscles accompanied by hyperactive stretch reflexes and often associated with a clasp-knife response. Under normal circumstances, a delicate balance exists between facilitating and inhibiting influences upon both alpha and gamma motor neurons, which together maintain appropriate control of skeletal muscle length and strength of contraction at the spinal cord level. After a stroke, input from one or more of the supraspinal reflex inhibitors decreases or stops entirely. The balance of control over the muscle favours facilitation, resulting in spasticity. Spasticity develops only if there is loss of input from both pyramidal and extrapyramidal motor systems.

The relationship between spasticity and HSP has been explored in several observational studies. In an early study, van Ouwenaller et al. (1986) identified spasticity as "the prime factor and the one most frequently encountered in the genesis of shoulder pain in the hemiplegic patient." In patients followed for one year after stroke, the authors identified a much higher incidence of shoulder pain in spastic (85%) than in flaccid (18%) hemiplegia. Poulin de Courval et al. (1990) similarly reported that subjects with shoulder pain had significantly more spasticity of the affected limb than those without pain. In contrast, Bohannon et al. (1986) and Joynt (1992) found that spasticity was unrelated to shoulder pain in patients with post-stroke hemiplegic shoulder.

Spastic Muscle Imbalance

Hemiplegia following stroke is characterized by typical posturing reflecting hypertonic muscle patterns. Flexor tone predominates in the hemiplegic upper extremity and results in scapular retraction and depression as well as internal rotation and adduction of the shoulder. This posture is the consequence of damage to higher centers and subsequent release of motor groups from pyramidal and extrapyramidal control. In stroke recovery, this "synergy pattern" of muscles is inevitable where recovery is incomplete, which can result in the development of spastic muscle imbalance around the shoulder joint.

The internal rotators of the shoulder predominate but are one of the last areas of shoulder function to recover. Motor units are not appropriately recruited during recovery, yielding the simultaneous co-contraction of agonist and antagonist muscles. A shortened agonist in the synergy pattern becomes stronger and the constant tension of the agonist can become painful; stretching of these tightened spastic muscles causes more pain. Tightened muscles inhibit movement, reduce range of motion, and prevent other movements, especially at the shoulder where external rotation of the humerus is necessary for arm abduction greater than 90°. Muscles that contribute to spastic internal rotation/adduction of the shoulder include the subscapularis, pectoralis major, teres major, and latissimus dorsi. However, two muscles in particular have been implicated as most often being spastic leading to muscle imbalance: (1) subscapularis and (2) pectoralis major.

Subscapularis Spasticity Disorder

The subscapularis muscle originates on the undersurface of the scapula and inserts on the lesser tuberosity of the humerus as well as the capsule of the shoulder joint (Figure 2). It is a major internal rotator of the shoulder (Hollinshead & Jenkins, 1981) and participates in arm adduction and extension from a flexed position (Cole & Tobis, 1990). In a normal state, nerve impulses to the subscapularis are inhibited during arm abduction; the muscle relaxes and allows the humerus to externally rotate, thus preventing impingement of the greater tuberosity on the acromion (Codman, 1934). As part of the typical flexor synergy pattern in those with spastic hemiplegia, internal rotators such as the subscapularis muscle are tonically active, which limits shoulder abduction, flexion, and external rotation (Bohannon et al., 1986; Hecht, 1995; Zorowitz et al., 1996).

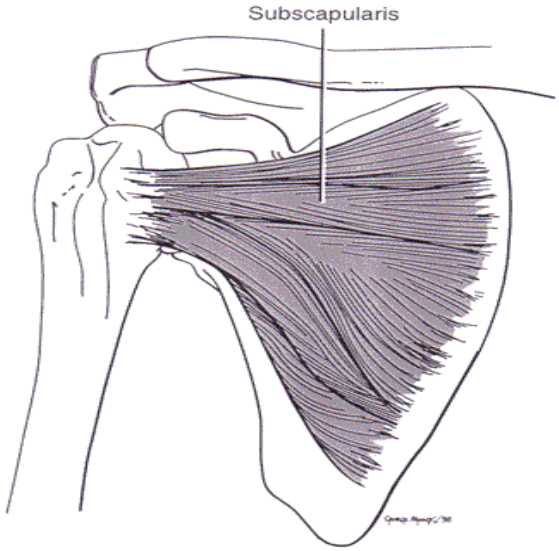


Figure 2. Subscapularis Muscle

Subscapularis spasticity disorder is characterized by motion being most limited and pain being reproduced on external rotation, as a tight band of spastic muscle is palpated in the posterior axillary fold. In fact, Inaba and Piorkowski (1972) reported external rotation was the most painful and limited movement of the hemiplegic shoulder. Subsequent studies have reported that limitation of external rotation of the hemiplegic shoulder was strongly correlated with HSP (Bohannon et al., 1986; Hecht, 1995; Zorowitz et al., 1996), suggesting that the subscapularis is “the keystone of the abnormal synergy pattern" (Hecht, 1995).

Pectoralis Spasticity Disorder

The pectoralis major muscle serves to forward flex, adduct, and internally rotate the arm, and is a synergist of the subscapularis muscle (Figure 3). Hecht (1995) reported on a subset of hemiplegic patients with greater limitations in abduction and flexion than on external rotation. In these patients, a spastic pectoralis major muscle appeared to be most problematic. This disorder is characterized by motion being most limited and pain produced on abduction.

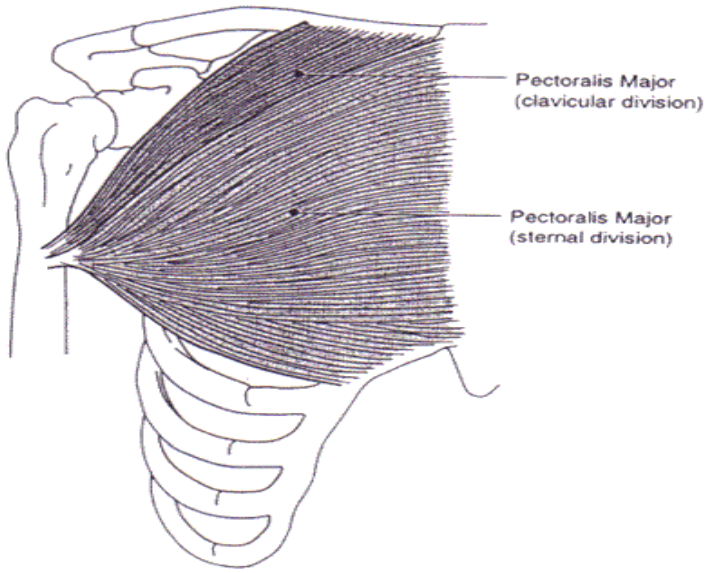


Figure 3. The Pectoralis Major Muscle

The importance of other shoulder muscles (i.e. biceps, pectoralis minor, and latissimus dorsi) have not been studied in the stroke population. A review by Kalichman & Ratmansky (2011) outlines a systematic approach to the underlying causes of HSP (Figure 11.3.2.3). The authors suggest that shoulder spasticity can lead to soft tissue lesions and/or altered peripheral and central nervous system activity, which can play a substantial role in evoking HSP. These issues may occur separately, co-exist simultaneously, or develop as a result of a trigger from a previous symptom (Kalichman & Ratmansky, 2011).

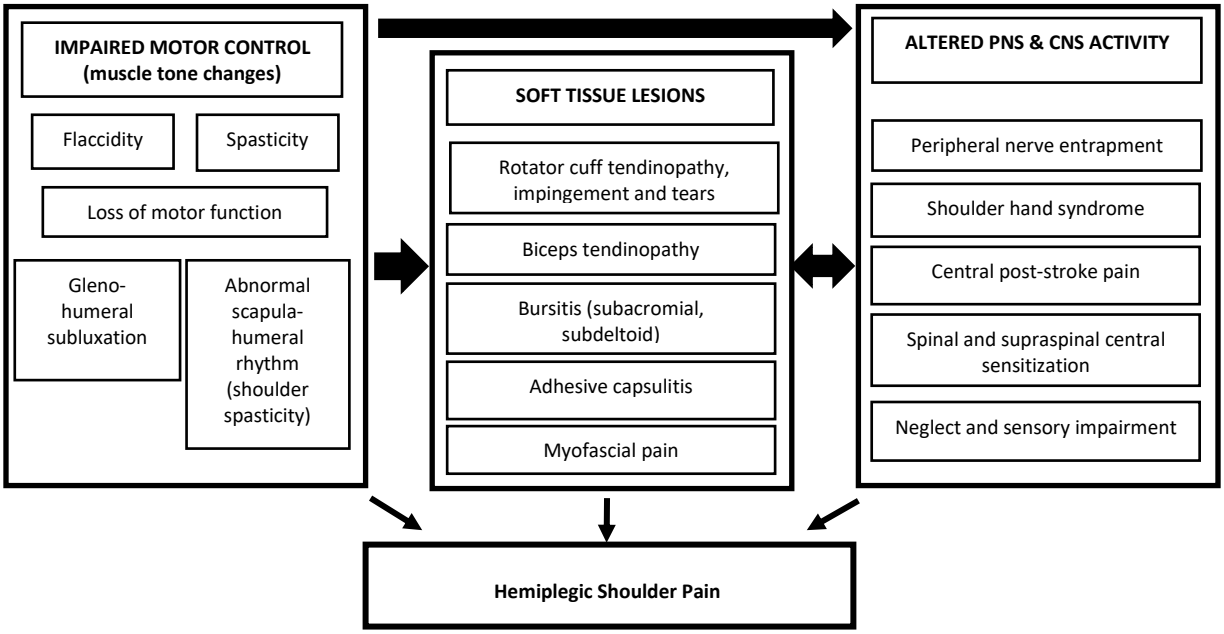


Figure 4. Underlying causes of hemiplegic shoulder pain (Adopted from Kalichman & Ratmansky, 2011).

Management of the hemiplegic shoulder

Shoulder Positioning and Range of Motion Exercises

Adopted from: https://www.saebo.com/regaining-shoulder-function-stroke-common-clinical-concerns-strategies/

The muscles around the hemiplegic shoulder are often paralyzed, initially with flaccid tone and later with spasticity. A primary goal of early stroke management is to prevent the development of hypertonicity and to discourage inefficient patterns (Johnstone 1982; Bobath 1990). Careful positioning of the shoulder serves to minimize subluxation early on and contractures later on, as well as to promote recovery. On the other hand, poor positioning may adversely affect symmetry, balance, and body image. It has been suggested that the ideal position for the upper limb is towards abduction, external rotation and flexion of the shoulder, although there is a lack of consensus regarding the specific positioning down to the exact degree (Bender & McKenna 2001).

Nine RCTs were found evaluating shoulder positioning and range of motion exercises for shoulder hemiplegia. Six RCTs when compared sustained positioning to conventional therapy (You et al. 2014; de Jong et al. 2006; Gustafsson & McKenna 2006; Ada et al. 2005; Turton & Britton 2005; Dean et al. 2000). Three RCTs when compared various range of motion exercises (Lynch et al. 2005; Kumar et al. 1990; Inaba & Piorkowski 1972).

The methodological details and results of all 9 RCTs are presented in Table 1.

Table 1. RCTs Evaluating Shoulder Positioning and Range of Motion Interventions for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Sustained positioning when compared to conventional therapy		
You et al. (2014) RCT (5) N_{start}=45 N_{end}=41 TPS=Chronic	E1: Stretching + joint-stabilizing exercise E2: Stretching exercise C: Standard exercise	E1 vs C: • Motor Assessment Scale (+exp$_1$) E1 vs E2: • Motor Assessment Scale (+exp$_2$) E2 vs C: • Motor Assessment Scale (-)
de Jong et al. (2006) RCT (7) N_{start}=19 N_{end}=19 TPS=Subacute	E: Sustained positioning C: Standard rehabilitation Duration: 30min/d (2x/d), 5d/wk for 5wk	• Reduction of Pain (-) • Passive Range of Motion (-) • Fugl-Meyer Assessment (-) • Modified Ashworth Scale (-)
Gustafsson & McKenna (2006) RCT (6) N_{start}=34 N_{end}=34 TPS=Chronic	E: Static positional stretches C: Standard rehabilitation Duration: 30min/d (2x/d), 5d/wk for 4wk	• Visual Analogue Scale (-) • Ritchie Articular Index (-) • Passive Range of Motion (-) • Motor Assessment Scale (-) • Modified Barthel Index (-)

Ada et al. (2005b)
RCT (8)
N_{start}=36
N_{end}=33
TPS=Acute
	E: Sustained positioning
	Position 1: maximum external rotation
	Position 2: 90° of flexion
	C: Standard rehabilitation
	Duration: 30 min/d (2x/d), 5d/wk for 4wk
		• Reduction of Pain (-)
		• Passive Range of Motion (-)
		• Motor Assessment Scale (-)
		• Contracture:
		  ○ Position 1 (+exp)
		  ○ Position 2 (-)

Turton & Britton (2005) UK RCT (6) N_{start}=25 N_{end}=25 TPS=Acute	E: Static positional stretches C: Standard rehabilitation Duration: 2hr/d, 3d/wk for 12wk	• Passive Range of Motion (-) • Contracture (-)
Dean et al. (2000) RCT (7) N_{start}=23 N_{end}=23 TPS=Subacute	E: Sustained positioning C: Standard rehabilitation Duration: 1hr/d, 5d/wk for 6wk	• Visual Analogue Scale (-) • Passive External Rotation (-) • Active Adduction (-)
Range of motion exercises		
Pain et al. (2020) RCT (8) N_{start}= 22 N_{end}= 19 TPS= Chronic Multi-site	E: 3D shoulder pain alignment protocol C: Conventional therapy Duration: 1hr 3x/wk, 4wks	• Shoulder Range of Motion: Flexion, Abduction (+exp) • Shoulder Range of Motion: External rotation (-)
Lynch et al. (2005) RCT (6) N_{start}=35 N_{end}=32 TPS=Acute	E: Continuous passive ROM exercises C: Self-ROM exercises Duration: 25min/d, 5d/wk for 4wk	• Reduction of Pain (Fugl-Meyer) (-) • Modified Ashworth Scale (-) • Fugl-Meyer Assessment (-) • Joint stability (-)
Kumar et al. (1990) RCT (5) N_{start}=28 N_{end}=28 TPS=Chronic	E1: ROM exercises E2: ROM exercises with skateboard E3: ROM exercises with overhead pulley Duration: 30min/d, 5d/wk for 4wk	E1 vs E3: • Reduction of Pain (+exp1) • Subluxation (-)

Inaba & Piorkowski (1972) RCT (7) N_{start}=33 N_{end}=33 TPS=Chronic	E1: ROM exercises + ultrasound E2: ROM exercises + positioning C: ROM exercises + mock ultrasound Duration: *Not Specified*	• Range of Motion (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Shoulder Positioning, and Range of Motion Exercises

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Sustained positioning** may not have a difference in efficacy when compared to **conventional therapy** for improving motor function.	1	De Jong et al. 2006
1b	**Continuous passive range of motion exercises** may not have a difference in efficacy when compared to **self-directed range of motion exercise** for improving motor function.	1	Lynch et al. 2005

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Sustained or static positioning** may not have a difference in efficacy when compared to **conventional therapy** for improving spasticity.	3	De Jong et al. 2006; Ada et al. 2005; Turton & Britton 2005
1b	**Continuous passive range of motion exercise** may not have a difference in efficacy when compared to **self-directed range of motion exercise** for improving spasticity.	1	Lynch et al. 2005

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Sustained or static positioning** may not have a difference in efficacy when compared to **conventional therapy** for improving range of motion.	5	De Jong et al. 2006; Gustafsson & McKenna 2006; Ada et al. 2005; Turton & Britton 2005; Dean et al 2000
1b	**Range of motion exercise with an ultrasound or positioning** may not have a difference in efficacy when compared to **range of motion exercise with a mock ultrasound** for improving range of motion.	1	Inaba & Piorkowski 1972

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**

1a	**Static positioning** may not have a difference in efficacy when compared to **conventional therapy** for improving activities of daily living.	2	Gustafsson & McKenna 2006; Ada et al., 2005b
2	**Stretching with joint stabilization exercise** may produce greater improvements in activities of daily living than **stretching or conventional therapy.**	1	You et al. 2014

MUSCLE STRENGTH			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Continuous passive range of motion exercise** may not have a difference in efficacy when compared to **self-directed range of motion exercise** for improving muscle strength.	1	Lynch et al. 2005

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Range of motion exercises** may produce greater improvements in pain than **range of motion exercises with use of an overhead pulley.**	1	Kumar et al. 1990
1a	**Sustained or static positioning** may not have a difference in efficacy when compared to **conventional therapy** for improving pain.	4	De Jong et al. 2006; Gustafsson & McKenna 2006; Ada et al. 2005; Dean et al. 2000
1b	**Continuous passive range of motion exercise** may not have a difference in efficacy when compared to **self-guided range of motion exercise** for improving pain.	1	Lynch et al. 2005

Key Points

Shoulder sustained positioning or range of motion exercise may not be beneficial for shoulder hemiplegia following stroke.

Orthotics

Adopted from https://www.sporlastic.de/en/product/artikel/neuro-lux-ii/, http://www.medicdepot.com/product/dynarex-3672-triangular-bandages-36-x-36-x-51-91cm-x-91cm-x-130cm/, https://www.alimed.com/skil-care-wheelchair-arm-support.html

There are various forms of orthotic devices, which are used to support the affected arm and shoulder. Arm slings are commonly used but are controversial due to potential disadvantages such as encouraging flexor synergies, inhibiting arm swing, contributing to contracture formation, and decreasing body image which may discourage the patient from further use of the affected arm. As tone returns to the shoulder muscle, the risk of shoulder subluxation decreases, and slings can then be withdrawn. Slings tend to hold the limb in a poor position, which may accentuate the adduction and internal rotation posture and may contribute to shortening of tonically active muscles. Another orthotic device, the Neuro-Lux shoulder joint functional orthosis, is designed to reposition the affected joint and reduce subluxation (Hartwig et al. 2012). Lastly, the modified wheelchair arm-support is an example of another supportive device, designed to reduce hemiplegic pain through assisting in the maintenance of normal posture (Pan et al. 2018).

Four RCTs were found evaluating orthotics for shoulder hemiplegia. Three RCTs investigated the effectiveness of slings (Ada et al. 2017; Van Bladel et al. 2017; Hartwig et al. 2012). One RCT compared modified wheelchair arm support with conventional therapy to traditional wheelchair arm support with conventional therapy (Pan et al. 2018).

The methodological details and results of all 4 RCTs are presented in Table 2.

Table 2. RCTs Evaluating Orthotics for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Liu et al. (2020) RCT (7) N_{start}= 50 N_{end}= 50 TPS= Subacute	E: Sling exercise therapy C: Conventional therapy Duration: 30min, 5x/wk, 4wks	• Barthel Index (-) • Fugle-Meyers Assessment Upper Extremity (+exp) • Visual Analogue Scale (shoulder) (+exp)
Jung et al. (2019) RCT (8) N_{start}= 36 N_{end}= 36 TPS= Acute	E: Shoulder sling exercise C: Bimanual tracking Duration: 40min, 5x/wk, 4wks	• Subluxation (+exp) • Shoulder Proprioception (+exp) • Fugle-Meyers Assessment Upper Extremity (+exp) • Manual Functional Test (+exp)
Ada et al. (2017) RCT (7) N_{start}=46 N_{end}=30 TPS=Acute	E: Lap-tray + triangular sling training C: Usual care hemi-sling training Duration: 10min/d for 4wk	• Shoulder Subluxation (-) • Visual Analogue Scale (-) • Range of Motion (-) • Motor Assessment Scale for Stroke (-)
Van Bladel et al. (2017) RCT (5) N_{Start}=32 N_{End}=28 TPS= Subacute	E1: Shoulder lift + conventional rehabilitation E2: Actimove + conventional rehabilitation C: No sling + conventional rehabilitation Duration: 6wk	• Subluxation and correction (-) • Range of Motion (-) • Fugl Meyer Assessment (-)
Hartwig et al. (2012) RCT (7) N_{start}=41 N_{end}=39 TPS=Acute	E: Functional orthosis (Neuro-Lux) C: No orthosis Duration: 30min/d, 5d/wk for 4wk	• Shoulder-Hand Syndrome score (+exp)
Pan et al. (2018) RCT (8) N_{Start}=120 N_{End}=114 TPS= Acute	E: Modified wheelchair arm support + conventional therapy C: Traditional wheelchair arm support + conventional therapy Duration: 60min/d, 6d/wk, for 4wk	• Visual Analogue Scale (-) • Numeric Pain Rating Scale (-) • Fugl-Meyer Assessment (-) • Modified Barthel Index (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Orthotics

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Modified wheelchair arm support** may not have a difference in efficacy when compared to **traditional wheelchair arm support** for improving motor function.	1	Pan et al. 2018
2	**Shoulder lift sling** may not have a difference in efficacy when compared to **conventional therapy**	1	Van Bladel et al. 2017

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Lap-tray with triangular sling training** may not have a difference in efficacy when compared to **conventional therapy with hemi-sling training** for improving range of motion.	1	Ada et al. 2017
2	**Shoulder lift sling with conventional therapy** may not have a difference in efficacy when compared to **conventional therapy** for improving range of motion.	1	Van Bladel et al. 2017

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Modified wheelchair arm support** may produce greater improvements in activities of daily living than **traditional wheelchair arm support.**	1	Pan et al. 2018
1b	**Lap-tray with triangular sling training** may not have a difference in efficacy when compared to **hemi-sling training with conventional therapy** for improving activities of daily living.	1	Ada et al. 2017

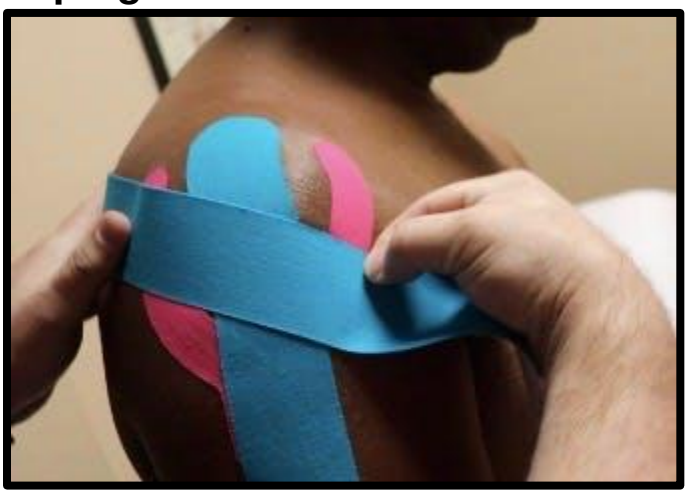
PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Functional orthosis (Neuro-Lux)** may produce greater improvements in pain than **no orthosis**	1	Hartwig et al. 2012
1b	**Lap-tray with triangular sling training** may not have a difference in efficacy when compared to **hemi-sling training with conventional therapy** for improving pain.	1	Ada et al. 2017
1b	**Modified wheelchair arm support** may not have a difference in efficacy when compared **to traditional wheelchair arm support** for improving pain.	1	Pan et al. 2018

Key Points

A functional orthosis may be beneficial for shoulder hemiplegia following stroke.

Slings are likely not beneficial for shoulder hemiplegia following stroke.

Taping



Adopted from: https://healthriteclinic.com/kinesio-taping/

Taping the hemiplegic shoulder is used as a method to prevent or reduce the severity of shoulder subluxation and may provide some sensory stimulation. There are various products and techniques that have been described previously, including those by Ancliffe (1992), Morin & Bravo (1997), and Hanger et al. (2000). More recently, researchers have explored approaches such as kinesio taping, California tri-pull taping, and neuromuscular taping (Jaraczewska & Long 2006; Hayner et al. 2012; Blow et al. 2012).

Ten RCTs were found evaluating shoulder taping for shoulder hemiplegia. Nine RCTs compared shoulder taping to sham taping or to no taping (Dos Santos et al. 2017; Huang et al. 2017; Chatterjee et al. 2016; Huang et al. 2016; Pillastrini et al. 2016; Pandian et al. 2013; Appel et al. 2011; Griffin & Bernhardt 2006; Hanger et al. 2000). One RCT compared shoulder taping to neuromuscular electrical stimulation (Hochsprung et al. 2017).

The methodological details and results of all 10 RCTs are presented in Table 3.

Table 3. RCTs Evaluating Taping Interventions for the Hemiplegic Shoulder.

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Shoulder taping compared to sham taping or no taping		
Comley-White et al. (2018) RCT (5) N_{start}= 56 N_{end}= 33 TPS= Acute	E1: Longitudinal strapping E2: Circumferential strapping C: Conventional therapy Duration: 2wks	E1 Vs C • Shoulder subluxation (-) • Richie articular index (-) • Modified Ashworth Scale (-) • Motor Assessment Scale: Upper Arm, Hand, Advanced Hand (-) E2 Vs C • Shoulder subluxation (-) • Richie articular index (-) • Modified Ashworth Scale (-) • Motor Assessment Scale: Upper Arm, Hand, Advanced Hand (-) E1 Vs E2 • Shoulder subluxation (-) • Richie articular index (-) • Modified Ashworth Scale (-) • Motor Assessment Scale: Upper Arm, Hand, Advanced Hand (-)
Dos Santos et al. (2017) RCT Crossover (7) N_{start}=13 N_{end}=29 TPS=Chronic	E: Elastic tape during joint position sense running assessment C: Sham tape during joint position sense running assessment Duration: Single use	• Shoulder subluxation (+exp) • Fugl-Meyer Assessment (+exp)
Huang et al. (2017) RCT (8) N_{start}=21 N_{end}=21 TPS=Subacute	E: Kinesio taping + conventional therapy C: Sham taping + conventional therapy Duration: 2d/wk, for 3wk	• Numerical Rating Scale for Shoulder Pain (+exp) • Shoulder Pain and Disability Index (+exp) • Pain-Free Passive Range of Motion: Flexion, External Rotation, Internal Rotation (+exp) • Visual Analog Scale (+exp) • Pain-Free Passive Range of Motion: Extension, Abduction, Adduction (-)
Chatterjee et al. (2016) RCT (7) N_{start}=30 N_{end}=30 TPS=Chronic	E: California tri-pull taping C: No taping Duration: 24hr/d, 5d/wk for 2wk	• Visual Analog Scale (+exp) • Active Shoulder Flexion (+exp) • Acromio-Humeral Distance (-) • Fugl-Meyer Assessment (-)
Huang et al. (2016b) RCT (7) N_{start}=49 N_{end}=44 TPS=Subacute	E: Kinesio taping C: No taping Duration: 24hr/d, 5d/wk for 1wk	• Visual Analog Scale (-) • Range of Motion (-) • Modified Ashworth Scale (-) • Fugl-Meyer Assessment (-) • Modified Barthel Index (-) • Stroke Specific Quality of Life (-)
Pillastrini et al. (2016) RCT (8) N_{start}=32 N_{end}=32 TPS=Chronic	E: Neuromuscular taping C: No taping Duration: 24hr/d, 1d/wk for 4wk	• Visual Analog Scale (+exp) • Modified Ashworth Scale (-) • Range of Motion (-)
Pandian et al. (2013) RCT (5)	E: Shoulder taping C: No taping	• Visual Analog Scale (+exp)

N_{start}=162 N_{end}=136 TPS=Acute	Duration: 24hr/d, 3d/wk for 4wk	• Shoulder Range of Motion (-) • Shoulder Pain and Disability Index (-)
Appel et al. (2011) RCT (5) N_{start}=14 N_{end}=14 TPS=Acute	E: Shoulder taping C: No taping Duration: Not Specified	• Motor Assessment Scale (+exp) • Fugl-Meyer Assessment (+exp) • 9-Hole Peg Test (+exp) • Stroke Specific Quality of Life Scale (+exp)
Griffin & Bernhardt (2006) RCT (6) N_{start}=33 N_{end}=31 TPS=Chronic	E: Shoulder taping C: Sham taping Duration: 24hr/d, 7d/wk for 4wk (straps reapplied every 3-4d)	• Visual Analog Scale (+exp) • Range of Motion (-) • Motor Assessment Scale (-) • Modified Ashworth Scale (-)
Hanger et al. (2000) RCT (7) N_{start}=98 N_{end}=87 TPS=Chronic	E: Shoulder taping C: No taping Duration: 24hr/d, 7d/wk for 3wk (straps reapplied every 3-5d)	• Visual Analog Scale (+exp) • Ritchie Articular Index (-) • Motor Assessment Scale (-) • Modified Rankin Scale (-) • Functional Independence Measure (-)
Shoulder taping compared to neuromuscular electrical stimulation		
Hochsprung et al. (2017) RCT (5) N_{start}=31 N_{end}=21 TPS=NR	E1: Kinesio taping group + physiotherapy E2: Neuromuscular electrical stimulation group + physiotherapy C: Conventional physiotherapy Duration: 25-30min/d for 4wk	• Visual Analogue Scale (-) • Barthel Index (-) • Action Research Arm Test (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp_2 indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Taping

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Shoulder taping** may not have a difference in efficacy compared to **no taping** for improving motor function.	4	Appel et al. 2011; Chatterjee et al. 2016; Huang et al. 2016; Pandian et al. 2013
2	**Shoulder taping** may not have a difference in efficacy compared to **neuromuscular electrical stimulation** for improving motor function.	1	Hochsprung et al. 2017

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Shoulder taping** may not have a difference in efficacy compared to **no taping** for improving spasticity.	3	Huang et al. 2016; Pillastrini et al. 2016; Griffin & Bernhardt 2006

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **shoulder taping** to improve range of motion when compared to **sham taping or no taping**.	5	Chatterjee et al. 2016; Huang et al. 2016b; Pillastrini et al. 2016; Griffin & Bernhardt

			2006; Huang et al. 2017

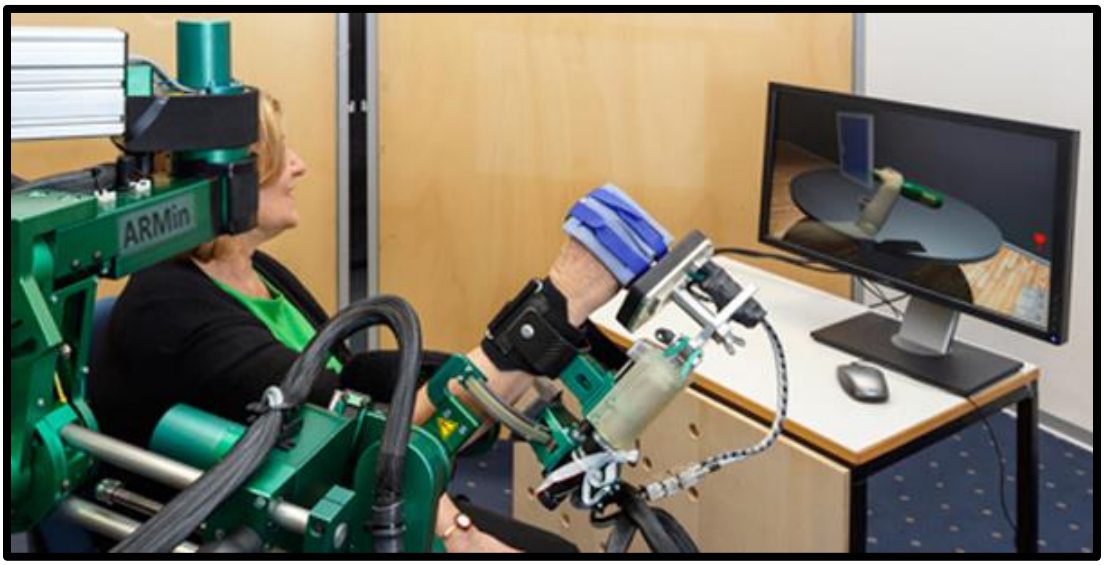
ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Shoulder taping** may not have a difference in efficacy compared to **sham taping or no taping** for improving activities of daily living.	4	Appel et al. 2011; Hanger et al. 2000; Huang et al. 2016b; Griffin & Bernhardt 2006
2	**Shoulder taping** may not have a difference in efficacy compared to **neuromuscular electrical stimulation** for improving activities of daily living.	1	Hochsprung et al. 2017

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Shoulder taping** may produce greater improvements in pain than **sham taping or no taping.**	7	Chatterjee et al. 2016; Hanger et al. 2000; Huang et al. 2016b; Pandian et al. 2013; Pillastrini et al. 2016; Griffin & Bernhardt 2006; Huang et al. 2017
2	**Shoulder taping** may not have a difference in efficacy compared to **neuromuscular electrical stimulation** for improving pain.	1	Hochsprung et al. 2017

Key Points

Shoulder taping may be effective for improving following stroke.
The literature is mixed regarding shoulder taping's benefit for improving range of motion
Shoulder taping may not be effective for improving motor function, spasticity, or activities of daily living following stroke.

Robotics



Adapted from: https://www.medgadget.com/2014/01/robotic-therapy-shown-effective-for-stroke-rehab.html

Traditionally, work in robotics for stroke recovery and rehabilitation focused on devices that could act to directly augment arm and shoulder movements to allow for greater functional use than the individual posses naturally. Now, research and development in this area is focused on robotics to assist in therapy and recovery of natural use (Burgar et al., 2000). Stroke rehabilitation is a laborious and time-consuming process for both the affected individual and their care team. In general, conventional rehabilitation requires (often many) therapists to assist and perform the therapy directly and in person. With a limited amount of manpower and financial resources, research is now focusing on technological methods that can potentially allow for a more optimized allocation of that manpower and financial resources. How to best implement robotic devices in conjunction with conventional physical therapy is still a major area of investigation.

One RCT was found that evaluated robotic solutions for hemiplegic shoulder rehabilitation. This study compared the use of a robotic-assisted physical therapy against conventional therapy.

The methodological details and results of the single RCT are presented in Table 4.

Table 4. RCTs Evaluating Robotics for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Ellis et al. (2009) RCT (4) N_{start}= 14 N_{end}= Not reported TPS= Not reported	E: Haptic master robot (progressive abduction shoulder loading) C: Robot sham Duration: 3x/wk, 8wks	• Work Area (+exp) • Shoulder Strength (-) • Elbow Strength (-)
Horsley et al. (2019) RCT (8) N_{start}= 50 N_{end}= 45 TPS= Acute	E: Repetitive task practice with SMART arm device (exoskeleton) C: Conventional therapy Duration: 60min, 5d/wk, 5wks + same amount of time for smart arm (not equal)	• Passive Range of Motion: Wrist Extension, Shoulder Flexion, Shoulder External Rotation (-) • Passive Range of Motion: Elbow Extension (+con) • Pain Visual Analogue Scale (movement, rest) (-)

		• Pain on Sleeping (-) • Motor Assessment Scale (-)
Kim et al. (2019) RCT (6) N_{start}= 38 N_{end}= 36 TPS= Subacute	E: Conventional physical therapy and additional robotic-assisted shoulder rehabilitation therapy C: Conventional therapy Duration: 30min, 10x plus 5x of additional robotic-assisted shoulder rehabilitation therapy for 4wks	• Visual Analogue Scale (+exp) • Passive Range of Motion: Flexion, External Rotation, Internal Rotation (-) • Passive Range of Motion: Abduction (+exp) • Korean-Shoulder Disability Questionnaire (+exp)
Jeon et al. (2016) RCT (5) N_{start}=12 N_{end}=12 TPS=Chronic	E: 'Monkey chair and band' therapy C: Conventional rehabilitation Duration: 30min/d, 3d/wk for 12wk	• Visual Analogue Scale (+exp) • Passive Range of motion (+exp) • Modified Motor Assessment Scale (+exp) •

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
$+exp_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Robotics

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Robotic-assisted physical therapy** may produce greater improvements in range of motion than **conventional therapy**	1	Jeon et al., 2016

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Robotic-assisted physical therapy** may produce greater improvements in pain than **conventional therapy**	1	Jeon et al., 2016

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Robotic-assisted physical therapy** may produce greater improvements in activities of daily living than **conventional therapy**	1	Jeon et al., 2016

Key Points

Robotics may be beneficial for improving range of motion, pain and activities of daily living in a hemiplegic shoulder.

Thermal Stimulation

Adopted from https://www.corechiropractic.net/articles/ice-therapy-cryotherapy/

Thermal stimulation is a recent technique within stroke rehabilitation which involves the use of heat or cold to promote upper extremity recovery (Gelnar et al. 1999; Davis et al. 1998). Cryotherapy, or cold therapy, is the use of low temperatures locally or generally, for medical purposes.

One RCT was found evaluating thermal stimulation for hemiplegic pain in which cryotherapy was compared to Bobath therapy (Partridge et al. 1990).

The methodological details and results of the one RCT is presented in Table 5.

Table 5. RCTs Evaluating Thermal Stimulation for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Partridge et al. (1990) RCT (5) N_{start}=65 N_{end}=62 TPS=Chronic	E: Cryotherapy C: Bobath therapy Duration: *Not Specified*	• Visual Analog Scale (+con)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Thermal Stimulation

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Cryotherapy** may not be superior in efficacy compared to **Bobath therapy** for improving pain.	1	Patridge et al. 1990

Key Points

Thermal stimulation may not be beneficial for reducing pain in shoulder hemiplegia following stroke.

Extracorporeal Shockwave Therapy

Adopted from http://www.eswtindia.com/shoulder.html

Extracorporeal shockwave therapy (ESWT) is an increasingly popular treatment option for musculoskeletal disorders (Wang 2012). ESWT works through a sequence of single sonic pulses which rise in pressure very quickly, have high peak pressure, and are short in duration (Kim et al. 2016). The shock waves are transmitted by a generator to specific target area (Kim et al. 2016). While the mechanism of function is not well understood, the most important factors of ESWT include pressure distribution, energy flux density, and the total acoustic energy (Wang 2012). These are used to produce interstitial and extracellular responses that encourage tissue regeneration (Ogden et al. 2001; Siebert & Buch 1997).

One RCT was found evaluating extracorporeal shockwave therapy for the hemiplegic shoulder in which extracorporeal shockwave therapy was compared to no stimulation (Kim et al. 2016).

The methodological details and results of the single RCT is presented in Table 6.

Table 6. RCTs Evaluating Extracorporeal Shockwave Therapy for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Kim et al. (2016) RCT (6) N_{start}=40 N_{end}=40 TPS=Chronic	E: Extracorporeal shockwave therapy C: No stimulation Duration: 45min/d, 4d/wk for 2wk	• Visual Analogue Scale (+exp) • Constant-Murley Scale (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Extracorporeal Shockwave Therapy

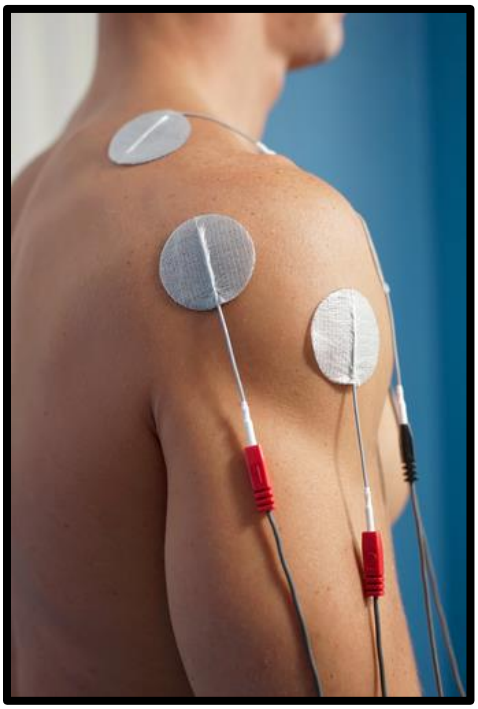
MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Extracorporeal shockwave therapy** may not have a difference in efficacy compared to **no stimulation** for improving motor function.	1	Kim et al. 2016

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Extracorporeal shockwave therapy** may produce greater improvements in pain than **no stimulation.**	1	Kim et al. 2016

Key Points

Extracorporeal shockwave therapy may be beneficial for improving pain, but not motor function in shoulder hemiplegia following stroke.

Interferential Current Therapy



Adopted from: https://www.currentchiro.com/interferential-current-therapy

Interferential current therapy (IFC) is a type of electrical stimulation that uses two alternating out of phase medium frequency sinusoidal currents to produce a low frequency current used for therapeutic purposes (De Domenico 1981; De Domenico 1987). IFC allows for deeper penetration with less skin resistance when compared to transcutaneous electrical nerve stimulation (TENS), which uses low frequency current (Low & Reed 2000). However, IFC is more expensive and less accessible than TENS (Palmer 1999).

Two RCTs were found evaluating interferential current therapy. One RCT compared interferential current therapy to low level light amplification by stimulated emission of radiation therapy (Jan et al. 2017). One RCT compared interferential current therapy to sham stimulation (Suriya-Amarit et al. 2014).

The methodological details and results of both RCTs are presented in Table 7.

Table 7. RCTs Evaluating Interferential Current Therapy for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Jan et al. (2017) RCT (6) N_{start}=38 N_{end}=38 TPS=NR	E: Low level light amplification by stimulated emission of radiation (LASER) therapy C: Interferential current (IFC) therapy Duration: 10min/d for 10d in experimental group, 30min/d for 10d in control group.	• Visual Analogue Scale (+exp) • Penn Shoulder Score- Satisfaction subscale (+exp) • Penn Shoulder Score- Pain subscale, Function subscale (-) • Shoulder Pain and Disability Index- Pain Subscale (+exp) • Shoulder Pain and Disability Index- Disability Subscale (-)
Suriya-Amarit et al. (2014) RCT (6) N_{start}=30 N_{end}=30 TPS=Subacute	E: Interferential current stimulation C: Sham stimulation Duration: 20min/d, 3d/wk for 4wk	• Numeric Pain Rating Scale (+exp) • Range of Motion (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Interferential Current Therapy

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Interferential current therapy** may not have a difference in efficacy compared to **low level light amplification by stimulated emission of radiation therapy** for improving motor function.	1	Jan et al. 2017

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Interferential current therapy** may produce greater improvements in range of motion than **sham therapy**	1	Suriya-Amarit et al. 2014

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Interferential current therapy** may produce greater improvements in pain than **sham therapy.**	1	Suriya-Amarit et al. 2014
1b	**Interferential current therapy** may not have a difference in efficacy compared to **low level light amplification by stimulated emission of radiation therapy** for improving stroke severity.	1	Jan et al. 2017

Key Points

Interferential current therapy may be more beneficial than sham therapy for improving shoulder hemiplegia after stroke.

Neuromuscular Electrical Stimulation

Adopted from http://fescenter.org/patient-resources/current-clinical-trials/stroke-programs/hand-function-control-2/hand-function-control/

Neuromuscular electrical stimulation (NMES) is a technique used to generate muscle contractions in regions affected by hemiparesis by stimulating lower motor neurons involved in muscle movement through the application of electrical current (Monte-Silva et al. 2019; Allen & Goodman 2014). NMES can be applied to a muscle transcutaneously or through an intramuscular probe (Knutson et al. 2015).

Two forms of NMES are available:

1. Cyclic NMES, in which a muscle is repetitively stimulated at near maximum contraction on a pre-set schedule and patient participation is passive (Nascimento et al. 2013);
2. Electromyography (EMG) triggered NMES, a target muscle is directly controlled or triggered by volitional EMG activity from the target or a different muscle to elicit a desired stimulation (Monte-Silva et al. 2019).

Additionally, when NMES is applied to assist during a voluntary functional task, it is referred to as functional electrical stimulation (FES) (Eraifej et al. 2017).High voltage pulsed galvanic stimulation is a form of neuromuscular electrical stimulation that uses higher voltages over a very short pulse duration to provide deeper penetration with less discomfort than traditional NMES (Newton 1984; Wong 1986).

A total of 16 RCTs were found evaluating NMES for shoulder hemiplegia following stroke.

Seven RCTs compared cyclic NMES to no therapy, conventional therapy, or sham stimulation (Zhou et al. 2018; Turkkan et al. 2017; De Jong et al. 2013; Church et al. 2006; Kobayashi et al. 1999; Linn et al. 1999; Baker & Parker 1986).Three RCTs compared intramuscular NMES to use of a sling (Chae et al. 2007a; Chae et al. 2005; Yu et al. 2004).One RCT compared electromyographic-triggered NMES with bilateral arm training to electromyographic-triggered transcutaneous electrical nerve stimulation with bilateral arm training (Chuang et al. 2017).Three RCTs compared functional electrical stimulation to no stimulation (Koyuncu et al. 2010; Wang et al. 2000; Faghri et al. 1994).One RCT compared task-oriented

electromyographic-triggered functional electrical stimulation to cyclic functional electrical stimulation (Jeon et al. 2017).One RCT compared high voltage pulsed galvanic stimulation with bobath therapy to bobath therapy alone (Fil et al. 2011).

The methodological details and results of all 16 RCTs are presented in Table 8.

Table 8. RCTs Evaluating Neuromuscular Electrical Stimulation for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Cyclic NMES vs no therapy, conventional therapy, or sham stimulation		

Zhou et al. (2018)
RCT (6)
N_{Start}=90
N_{End}=62
TPS=Subacute
	E1: Cyclic NMES
	E2: TENS
	C: Conventional therapy
	Duration: 1h/d, 5d/wk, for 4wk.
		• Active/ Passive Range of Motion (-)
		• Fugl-Meyer Assessment (-)
		• Modified Ashworth Scale (-)
		• Barthel Index (-)
		• Stroke-Specific Quality of Life Scale (-)
		• E1 vs C:
		  ○ Numerical Pain Rating Scale (+exp1)
		• E2 vs C:
		  ○ Numerical Pain Rating Scale (+exp2)
		• E1 vs E2:
		  ○ Numerical Pain Rating Scale (+exp1)

Turkkan et al. (2017) RCT (6) N_{Start}=24 N_{End}=24 TPS= Acute	E: Cyclic NMES C: Conventional therapy Duration: 60min/d, 5d/wk for 4wk	• Shoulder Disability Questionnaire (+exp) • Acromion-greater tuberosity distance (+exp) • Supraspinatus muscle thickness (+exp) • Brunnstrom motor recovery stages (-) • Visual Analogue Scale (-) • Muscle thickness (-)
De Jong et al. (2013) RCT (8) N_{start}=48 N_{end}=39 TPS=Acute	E: Cyclic NMES + Static arm positioning C: Sham stimulation + Sham arm positioning Duration: 45min/d (2x/d), 5d/wk for 8wk	• ShoulderQ (-) • Range of Motion (-)
Church et al. (2006) RCT (9) N_{start}=176 N_{end}=155 TPS=Acute	E: Cyclic NMES C: Sham stimulation Duration: 30min/d, 3d/wk for 4wk	• Numerical Pain Rating Scale (-) • Action Research Arm Test (-) • Motricity Index: (+con) • Frenchay Arm Test: (+con)

Kobayashi et al. (1999)
RCT (5)
N_{start}=115
N_{end}=96
TPS=Chronic
	E1: Cyclic NMES to supraspinatus
	E2: Cyclic NMES to middle deltoid
	C: No stimulation
	Duration: 15min/d (2x/d), 3d/wk for 6wk
		• E1 vs C:
		  ○ Subluxation (+exp1)
		  ○ Abduction (-)
		• E2 vs C:
		  ○ Subluxation (+exp2)
		  ○ Abduction (+exp2)

Linn et al. (1999) RCT (6) N_{start}=40 N_{end}=36 TPS=Acute	E: Cyclic NMES C: No stimulation Duration: 45min/d, 3d/wk for 4wk	• Pain Reduction (+exp) • Subluxation (+exp)
Baker & Parker (1986)	E: Cyclic NMES	• Subluxation (+exp)

RCT (4) N_{start}=63 N_{end}=63 TPS=Chronic	C: No stimulation Duration: Not Specified	
Intramuscular NMES vs sling		
Chae et al. (2007a) RCT (7) N_{start}=61 N_{end}=34 TPS=Chronic	E: Intramuscular NMES C: Sling Duration: 6hr/d, 5d/wk for 6wk	• Brief Pain Inventory (+exp) • Passive Range of Motion (-) • Functional Independence Measure (-) • Arm Motor Ability Test (-) • Fugl-Meyer Assessment (-) • Subluxation (-)
Chae et al. (2005) RCT (7) N_{start}=61 N_{end}=43 TPS=Chronic	E: Intramuscular NMES C: Sling Duration: 6hr/d, 5d/wk for 6wk	• Brief Pain Inventory (+exp) • Passive Range of Motion (-) • Functional Independence Measure (-) • Action Research Arm Test (-) • Fugl-Meyer Assessment (-) • Subluxation (-)
Yu et al. (2004) RCT (7) N_{start}=61 N_{end}=50 TPS=Chronic	E: Intramuscular NMES C: Sling Duration: 6hr/d, 5d/wk for 6wk	• Brief Pain Inventory (+exp) • Passive Range of Motion (-) • Functional Independence Measure (-) • Arm Motor Ability Test (-) • Fugl-Meyer Assessment (-) • Subluxation (-)
EMG-NMES with bilateral arm training vs. EMG-TENS with bilateral arm training		
Chuang et al. (2017) RCT (7) N_{Start}=38 N_{End}=38 TPS=Chronic	E: EMG-NMES + bilateral arm training C: EMG-TENS + bilateral arm training	• Passive Range of Motion (-) • Numerical Pain Rating Scale with a Faces Rating Scale (+exp) • Short Form Brief Pain Inventory (+exp) • Fugl-Meyer Assessment (-)
FES vs. no stimulation		
Koyuncu et al. (2010) RCT (4) N_{start}=50 N_{end}=50 TPS=Chronic	E: FES C: No stimulation Duration: 30min/d, 3d/wk for 6wk	• Visual Analogue Scale (-) • Passive and Active Range of Motion (-) • Subluxation (+exp)
Wang et al. (2000) RCT (5) N_{start}=32 N_{end}=28 TPS=Chronic	E: FES C: No stimulation Duration: 45min/d, 3d/wk for 4wk	• Subluxation, short-duration hemiplegia reduction (+exp) • Subluxation, long-duration hemiplegia reduction (-)
Faghri et al. (1994) RCT (4) N_{start}=26 N_{end}=26 TPS=Acute	E: FES C: No stimulation Duration: 6hr/d, 5d/wk for 6wk	• Spasticity (+exp) • Motor function (+exp)
Task-oriented EMG-FES vs cyclic FES		
Jeon et al. (2017) RCT (5) N_{start}=20 N_{end}=20 TPS= Subacute	E: Task-oriented electromyography triggered functional electrical stimulation C: Functional electrical stimulation Duration: 30min/d, 5d/wk for 4wk	• Fugl-Meyer Assessment shoulder subscale (+exp) • Visual Analogue Scale (+exp) • Muscle activation (+exp) Shoulder subluxation (+exp)
High voltage pulsed galvanic stimulation with bobath therapy vs bobath therapy		
Fil et al. (2011) RCT (5) N_{start}=48 N_{end}=48 TPS=Acute	E: High voltage pulsed galvanic stimulation + Bobath therapy C: Bobath therapy Duration: *Not Specified*	• Subluxation (+exp) • Shoulder joint displacement (+exp) • Motor Assessment Scale (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about neuromuscular electrical stimulation

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Cyclic neuromuscular electrical stimulation** may not have a difference in efficacy compared to **conventional therapy or sham stimulation** for improving motor function.	3	Zhou et al. 2018; Turkkan et al. 2017; Church et al. 2006
1a	**Intramuscular neuromuscular electrical stimulation** may not have a difference in efficacy compared to **use of a sling** for improving motor function.	3	Chae et al. 2005; Yu et al. 2004; Chae et al. 2007a
1b	**Electromyographic-triggered neuromuscular electrical stimulation with bilateral arm training** may not have a difference in efficacy compared to **electromyographic-triggered transcutaneous electrical nerve stimulation with bilateral arm training** for improving motor function.	1	Chuang et al. 2017
1b	There is conflicting evidence about the effect of **task-oriented electromyographic-triggered functional electrical stimulation** to improve motor function when compared to **cyclic functional electrical stimulation**.	1	Jeon et al. 2017
1b	There is conflicting evidence about the effect of **functional electrical stimulation** to improve motor function when compared to **no stimulation.**	1	Faghri et al. 1994

DEXTERITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Cyclic neuromuscular electrical stimulation** may not have a difference in efficacy compared to **sham stimulation** for improving dexterity.	1	Church et al. 2006

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Cyclic neuromuscular electrical stimulation** may not have a difference in efficacy compared to **conventional therapy** for improving spasticity.	1	Zhou et al. 2018
2	**Functional electrical stimulation** may produce greater improvements in spasticity than **no stimulation**	1	Faghri et al. 1994

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Cyclic neuromuscular electrical stimulation** may not have a difference in efficacy compared to **conventional therapy or sham stimulation** for improving range of motion.	3	Zhou et al. 2018; Turkkan et al. 2017; De Jong et al. 2013
1a	**Intramuscular neuromuscular electrical stimulation** may not have a difference in efficacy compared to **use of a sling** for improving range of motion.	3	Chae et al. 2005; Yu et al. 2004; Chae et al. 2007a
1b	**Electromyographic-triggered neuromuscular electrical stimulation with bilateral arm training** may not have a difference in efficacy compared to **electromyographic-triggered transcutaneous electrical nerve stimulation with bilateral arm training** for improving range of motion.	1	Chuang et al. 2017
2	**Functional electrical stimulation** may not have a difference in efficacy compared to **no stimulation** for improving range of motion.	1	Koyuncu et al. 2010

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Intramuscular neuromuscular electrical stimulation** may not have a difference in efficacy compared to **use of a sling** for improving activities of daily living.	3	Chae et al. 2005; Yu et al. 2004; Chae et al. 2007a
1b	**Cyclic neuromuscular electrical stimulation** may not have a difference in efficacy compared to **conventional therapy** for improving activities of daily living.	1	Zhou et al. 2018
2	**High voltage pulsed galvanic stimulation with bobath therapy** may not have a difference in efficacy compared to **bobath therapy** for improving activities of daily living.	1	Fil et al. 2011

MUSCLE STRENGTH			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **cyclic neuromuscular electrical stimulation** to improve muscle strength when compared to **no therapy, conventional therapy, or sham stimulation**.	3	Turkkan et al. 2017; Church et al. 2006; Kobayashi et al. 1999

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**

1a	**Intramuscular neuromuscular electrical stimulation** may produce greater improvements in pain than **use of a sling.**	3	Chae et al. 2005; Yu et al. 2004; Chae et al. 2007a
1a	There is conflicting evidence about the effect of **cyclic neuromuscular electrical stimulation** to improve stroke severity when compared to **no therapy, conventional therapy, or sham stimulation**.	5	Zhou et al. 2018; Turkkan et al. 2017; De Jong et al. 2013; Church et al. 2006; Linn et al. 1999
1b	**Electromyographic-triggered neuromuscular electrical stimulation with bilateral arm training** may produce greater improvements in pain than **electromyographic-triggered transcutaneous electrical nerve stimulation with bilateral arm training.**	1	Chuang et al. 2017
2	**Task-oriented electromyographic-triggered functional electrical stimulation** may produce greater improvements in pain than **cyclic functional electrical stimulation.**	1	Jeon et al. 2017
2	**Functional electrical stimulation** may not have a difference in efficacy compared to **no stimulation** for improving pain.	1	Koyuncu et al. 2010

Key Points

The literature is mixed regarding cyclic neuromuscular electrical stimulation for shoulder hemiplegia following stroke.

Intramuscular or electromyographic-triggered neuromuscular electrical stimulation for shoulder hemiplegia may be beneficial for improving pain, but not other outcomes following stroke.

The literature is mixed regarding functional electrical stimulation for shoulder hemiplegia following stroke.

The literature is mixed regarding high voltage pulsed galvanic stimulation for shoulder hemiplegia following stroke.

Repetitive Transcranial Magnetic Stimulation

Adopted from https://www.statnews.com/2016/04/19/autism-book/

Transcranial magnetic stimulation (TMS) is a non-invasive brain stimulation technique that makes use of an electromagnetic field through a coil placed on the scalp which induces a change in electrical fields of the brain (Peterchev et al. 2012). The voltage and current of the electromagnetic field generated are dependent on the parameters of the stimulation device, which is not distorted by the biological tissues in which it is applied (Peterchev et al. 2012). The neuromodulatory effects of transcranial magnetic stimulation are attributed largely to neural membrane polarization shifts that can lead to changes in neuron activity, synaptic transmission, and activation of neural networks (Peterchev et al. 2012). Repetitive transcranial magnetic stimulation (rTMS) is the application of the repetitive trains of transcranial magnetic stimulation at regular intervals.

After a stroke, interhemispheric competition is altered, with cortical excitability increasing in the unaffected hemisphere and decreasing in the affected hemisphere (Zhang et al. 2017). rTMS can be used to help modulate this interhemispheric competition, with low stimulation frequencies (≤ 1Hz) decreasing cortical excitability, and inhibiting activity of the contralesional hemisphere. Meanwhile, high frequency (> 1Hz) stimulation increases excitability and have a facilitatory effect on activity of the ipsilesional hemisphere (Dionisio et al. 2018).

One RCT was found evaluating repetitive transcranial magnetic stimulation for shoulder hemiplegia. The RCT compared repetitive transcranial magnetic stimulation to sham stimulation (Choi et al. 2017).

The methodological details and results of the RCT are presented in Table 9.

Table 9. RCTs Evaluating Repetitive Transcranial Magnetic Stimulation for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Choi et al. (2017) RCT (8) N_{Start}=24 N_{End}=24 TPS=Chronic	E: High-frequency (10 Hz) Repetitive transcranial magnetic stimulation C: Sham stimulation Duration: 10 sessions/d, 5d/wk, for 2wk	• Numeric Rating Scale (+exp) • Passive Range of Motion (-) • Upper Limb Motricity Index (-) • Modified Brunnstrom Classification (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Repetitive Transcranial Magnetic Stimulation

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Repetitive transcranial magnetic stimulation** may not have a difference in efficacy compared to **sham stimulation** for improving motor function.	1	Choi et al. 2017

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Repetitive transcranial magnetic stimulation** may not have a difference in efficacy compared to **sham stimulation** for improving range of motion.	1	Choi et al. 2017

MUSCLE STRENGTH			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Repetitive transcranial magnetic stimulation** may not have a difference in efficacy compared to **sham stimulation** for improving muscle strength.	1	Choi et al. 2017

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Repetitive transcranial magnetic stimulation** may produce greater improvements in pain than **sham stimulation.**	1	Choi et al. 2017

Key Points

Repetitive transcranial magnetic stimulation is likely beneficial for reducing pain in shoulder hemiplegia, but not for improving motor function, range of motion, or muscle strength post stroke.

Electrical Nerve Stimulation

Adopted from https://nerve-injury.com/transcutaneous-electrical-nerve-stimulation/, https://www.eurekalert.org/multimedia/pub/125134.php

Electrical nerve stimulation can be divided into invasive or non-invasive methods.

Transcutaneous electrical stimulation (TENS) is a non-invasive peripheral stimulation in which pulsed electrical currents are delivered to the surface of the skin to stimulate the underlying nerves (Johnson 2007). TENS is typically administered using a portable hand-held stimulating device and electrode pads (Johnson 2007; Teoli et al. 2019). Stimulation can be applied at a low frequency (<10 Hz) to produce muscle contractions, or at a high (>50 Hz) frequency primarily used to produce paresthesia without muscle contractions (Teoli et al. 2019). The application of afferent electrical stimulation at the sensory level may help to enhance neuroplasticity of the brain through increased activation and recruitment of cortical networks involving contralesional primary sensory cortex, supplementary motor area, dorsal premotor cortex, posterior parietal cortex, and secondary sensory cortices (Veldman et al. 2015; Sonde et al. 1998).

Peripheral nerve stimulation (PNS) is an invasive technique in which a wire-like electrode is implanted next to a peripheral nerve (Nayak & Banik 2018). Electricity is then delivered from a generator to the nerve through the electrode with the primary purpose of reducing pain at the site (Nayak & Banik 2018).

A total of three RCT evaluated electrical nerve stimulation for shoulder hemiplegia. One RCT compared non-invasive TENS to ultrasound therapy (Moniruzzaman et al. 2010). Two RCTs compared invasive PNS to either conventional therapy or no stimulation (Wilson et al. 2014; Wilson et al. 2017).

The methodological details and results of all 3 RCTs are presented in Table 10.

Table 10. RCTs Evaluating Electrical Nerve Stimulation for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Non-invasive electrical nerve stimulation vs ultrasound therapy		
Moniruzzaman et al. (2010) RCT (4) N_{start}=45 N_{end}=45 TPS=Chronic	E: Non-invasive TENS C: Ultrasound therapy Duration: 45min/d, 3d/wk for 5wk	• Lattinen Index (-) • Range of Motion (+exp) • Muscle strength (+exp)
Invasive electrical nerve stimulation vs conventional therapy or no stimulation		
Wilson et al. (2014) RCT (9) N_{Start}=25 N_{End}=21 TPS=Subacute	E: Invasive PNS C: No stimulation Duration: 45min/d, 5d/wk for 4wk	• Brief Pain Inventory (+exp)
Wilson et al. (2017) RCT (7) N_{Start}=25 N_{End}=22 TPS=Chronic	E: Invasive PNS C: Conventional therapy + recommended home exercise program Duration: 6h/d, 7d/wk, for 3wk	• Fugl-Meyer Assessment (-) • Shoulder abductor moment (-) • Pain free abduction (-) • Delay in EMG initiation or termination (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Electrical Nerve Stimulation

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Invasive peripheral nerve stimulation** may not have a difference in efficacy compared to **conventional therapy** for improving motor function.	1	Wilson et al. 2017

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Non-invasive transcutaneous electrical nerve stimulation** may produce greater improvements in range of motion than **ultrasound therapy**	1	Moniruzzaman et al. 2010
1b	**Invasive peripheral nerve stimulation** may not have a difference in efficacy compared to **conventional therapy** for improving range of motion.	1	Wilson et al. 2017

MUSCLE STRENGTH			
LoE	**Conclusion Statement**	**RCTs**	**References**

2	**Non-invasive transcutaneous electrical nerve stimulation** may produce greater improvements in muscle strength than **ultrasound therapy.**	1	Moniruzzaman et al. 2010

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Invasive peripheral nerve stimulation** may produce greater improvements in pain than **no stimulation.**	1	Wilson et al. 2014
2	**Non-invasive transcutaneous electrical nerve stimulation** may not have a difference in efficacy compared to **ultrasound therapy** for improving pain.	1	Moniruzzaman et al. 2010

Key Points

The literature is mixed regarding non-invasive transcutaneous electrical nerve stimulation and invasive peripheral nerve stimulation for shoulder.

Botulinum Toxin

Adopted from http://m.theinvestor.co.kr/view.php?ud=20180104000712

Botulinum toxin exerts a therapeutic effect by reducing overactivity in spastic muscles through blocking the release of acetylcholine at the neuromuscular junction. The benefits of botulinum toxin injections are generally dose-dependent and last approximately 2 to 4 months (Brashear et al. 2002; Francisco et al. 2002; Simpson et al. 1996; Smith et al. 2000). One of the advantages of botulinum toxin is that it is safe to use on small, localized areas or muscles, such as those in the upper extremity. Unlike chemodenervation and neurolytic procedures like phenol or alcohol, botulinum toxin is not associated with skin sensory loss or dysesthesia (Suputtitada & Suwanwela, 2005). Dynamic EMG studies can be helpful in determining which muscles should be injected (Bell & Williams, 2003).

There are three common types of botulinum neurotoxin type A products that are available, including onabotulinum toxin-A (ONA; Botox), abobotulinum toxin-A (ABO; Dsyport), and incobotulinum toxin-A (INCO; Xeomin). While their efficacy and mechanism of action are considered to be comparable, there are notable differences in potency and conversion ratios (Scaglione 2016). While the conversion ratio between ONA and INCO is very close to 1:1, the ratio between ONA and ABO differs (Benecke et al. 2005; Roggenkamper et al. 2006; Jost et al. 2005; Park et al. 2011; Zoons et al. 2012). The most commonly accepted ratio of ONA to ABO is 1:3 or 1:4 (Aoki et al. 2006; Scaglione 2016).

A total of 6 RCTs were found evaluating botulinum toxin for shoulder hemiplegia following stroke.

4 RCTs compared Botulinum toxin A (Botox or Dysport) to placebo (Marciniak et al. 2012; De Boer et al. 2008; Kong et al. 2007; Yelnik et al. 2007). One RCT compared Botox with conventional therapy to Botox alone (Devier et al. 2017). One RCT compared Dysport with electrical stimulation to placebo with electrical stimulation (Marco et al. 2007).

The methodological details and results of all 6 RCTs are presented in Table 11.

Table 11. RCTs Evaluating Botulinum Toxin for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Botulinum toxin A (Botox, Dysport) vs placebo		
Marciniak et al. (2012) RCT (10) N_{start}=21 N_{end}=19 TPS=Chronic	E: 140-200U Botox C: Placebo Duration: 100-150U Botox 1d/wk for 4wk	• Disability Assessment Scale (+exp) • Functional Independence Measure (-) • McGill Pain Questionnaire (-) • Range of Motion (-) • Modified Ashworth Scale (-)
de Boer et al. (2008) RCT (6) N_{start}=22 N_{end}=22 TPS=Subacute	E: 100U Botox C: Placebo Duration: *Not Specified*	• Visual Analog Scale (-) • Range of Motion (-) • Modified Ashworth Scale (-)
Kong et al. (2007) RCT (8) N_{start}=17 N_{end}=17 TPS=Subacute	E: 500U Dysport (diluted with 2.5mL saline) C: Placebo (2.5mL saline) Duration: 500U Dysport (diluted with 2.5mL saline) 1d/wk for 6wk	• Visual Analog Scale (-) • Modified Ashworth Score (-) • Range of Motion (-)
Yelnik et al. (2007) RCT (7) N_{start}=20 N_{end}=20 TPS=Chronic	E: 500U Dysport C: Placebo Duration: Single Injection of 500U Dysport	• Visual Analog Scale (+exp) • Range of Motion (+exp) • Modified Ashworth Scale (+exp)
Botox with conventional therapy vs Botox		
Devier et al. (2017) RCT (5) N_{start}=31 N_{end}=29 TPS=Chronic	E: Botox + conventional therapy C: Botox Duration: *Not Specified*	• Fugl-Meyer Assessment (+exp) • Modified Ashworth Scale (-)
Dysport with electrical stimulation vs. placebo with electrical stimulation		
Marco et al. (2007) RCT (8) N_{start}=31 N_{end}=29 TPS=Chronic	E: Electrical stimulation + 500U Dysport C: Electrical stimulation + placebo Duration: Electrical Stimulation (30min at a time) + 500U Dysport 2d/wk for 6wk	• Visual Analogue Scale (+exp) • Modified Ashworth Score (-) • Shoulder Range of Motion (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Botulinum Toxin

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Botulinum toxin A with conventional therapy** may produce greater improvements in motor function than **Botulinum toxin A.**	1	Devier et al. 2017

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Botulinum toxin A** may not have a difference in efficacy compared to **placebo** for improving spasticity.	4	Marciniak et al. 2012; de Boer et al. 2008; Kong et al. 2007; Yelnik et al. 2007
1b	**Botulinum toxin A with electrical stimulation** may not have a difference in efficacy compared to **placebo with electrical stimulation** for improving spasticity.	1	Marco et al. 2007
2	**Botulinum toxin A with conventional therapy** may not have a difference in efficacy when compared to **Botulinum toxin A** for improving spasticity.	1	Devier et al. 2017

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Botulinum toxin A with electrical stimulation** may produce greater improvements in range of motion than **placebo with electrical stimulation**	1	Marco et al. 2007
1a	**Botulinum toxin A** may not have a difference in efficacy compared to **placebo** for improving range of motion.	4	De Boer et al. 2008; Marciniak et al. 2012; Kong et al. 2007; Yelnik et al. 2007

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Botulinum toxin A with electrical stimulation** may produce greater improvements in pain than **placebo with electrical stimulation.**	1	Marco et al. 2007
1a	**Botulinum toxin A** may not have a difference in efficacy when compared to **placebo** for improving pain.	4	De Boer et al. 2008; Marciniak et al. 2012; Kong et al. 2007; Yelnik et al. 2007

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **Botulinum toxin A** to improve activities of daily living when compared to **placebo**.	1	Marciniak et al. 2012

Key Points

Botulinum toxin A may not be beneficial for improving shoulder hemiplegia after stroke.

Steroids

Adopted from https://www.clearskypharmacy.biz/generic-kenalog-kenacort-by-nicholas-piramal.html

Triamcinolone acetonide is a corticosteroid hormone, or glucocorticoid, that is typically administered through intramuscular, intradermal, or intra-articular routes. Intra-articular corticosteroid injections are a common method for treating shoulder hemiplegia and are typically used to reduce pain and improve range of motion and function (Rah et al. 2012; Yasar et al. 2011). Another variation is subacromial corticosteroid injection, but evidence of this approach is extremely limited (Rah et al. 2012).

A total of 6 RCTs were found evaluating Triamcinolone Acetonide injections for shoulder hemiplegia following stroke.

Three RCTs compared Triamcinolone Acetonide to either conventional therapy or a placebo injection (Baykal et al. 2013; Rah et al. 2012; Snels et al. 2000).One RCT compared Triamcinolone Acetonide to a suprascapular nerve block (Yasar et al. 2011). One RCT compared Triamcinolone Acetonide to botulinum toxin A (Lim et al. 2008). One RCT compared Triamcinolone Acetonide with transcutaneous electrical nerve stimulation to transcutaneous electrical nerve stimulation alone (Lakse et al. 2009).

The methodological details and results of all 6 RCTs are presented in Table 12.

Table 12. RCTs Evaluating Triamcinolone Acetonide for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Triamcinolone acetonide vs placebo or conventional therapy		
Baykal et al. (2013) RCT (4) N_{start}=30 N_{end}=30 TPS=Chronic	E: Intra-articular triamcinolone acetonide (40mg) + conventional physiotherapy C: No injection + conventional therapy Duration: Single Injection of Triamcinolone Actonide (40mg) plus conventional physiotherapy (1hr/d, 3d/wk for 5wk)	• Visual Analogue Scale (-) • Range of Motion (-) • Modified Ashworth Scale (-) • Functional Independence Measure (-) • Brunnstrom Recovery Stages (-)
Rah et al. (2012) RCT (9) N_{start}=58 N_{end}=54 TPS=Chronic	E: Ultrasound-guided subacromial injection of triamcinolone acetonide injection(40mg) C: Lidocaine placebo injection Duration: Single Injection of Triamcinolone Acetonide (40mg)	• Visual Analogue Scale (+exp) • Flexion (+exp) • Active Range of Motion (+exp) • Shoulder Disability Questionnaire (+exp)
Snels et al. (2000) RCT (8) N_{start}=35 N_{end}=35 TPS=Chronic	E: Intra-articular triamcinolone acetonide (40mg) C: Saline placebo Duration: Single Injection of Triamcinolone Acetonide (40mg)	• Visual Analogue Scale (-) • Action Research Arm Test (-) • Fugl-Meyer Assessment (-)
Triamcinolone acetonide vs nerve block or botulinum toxin		
Yasar et al. (2011) RCT (5) N_{start}=26 N_{end}=26 TPS=Chronic	E1: Suprascapular nerve block E2: Intra-articular triamcinolone acetonide injection (40mg) Duration: Single Injection of Triamcinolone Acetonide (40mg)	• Visual Analogue Scale (-) • Range of Motion (-)
Lim et al. (2008) RCT (9) N_{start}=29 N_{end}=22 TPS=Chronic	E1: Intra-articular triamcinolone acetonide injection (40mg) E2: Intramuscular botulinum toxin A (100U) Duration: *Not Specified*	• Numeric Rating Scale (-) • Passive Range of Motion (-) • Fugl-Meyer Assessment (-) • Modified Ashworth Scale (-)
Triamcinolone acetonide with TENS vs TENS		
Lakse et al. (2009) RCT (4) N_{start}=38 N_{end}=35 TPS=Chronic	E: Intra-articular triamcinolone acetonide (40mg) + TENS C: No injection + TENS Duration: Single Injection of Triamcinolone Acetonide (40mg) + TENS (20min/d, 5d/wk for 3wk)	• Verbal Analogue Scale (+exp) • Passive Range of Motion (+exp) • Modified Ashworth Scale (-) • Barthel Index (-) • Brunnstrom Recovery Stages (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Steroids

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	There is conflicting evidence about the effect of **Triamcinolone acetonide** to improve motor function when compared to **conventional therapy or placebo**.	3	Rah et al. 2012; Baykal et al. 2013; Snels et al. 2000
1b	**Triamcinolone acetonide** may not have a difference in efficacy compared to **botulinum toxin** for improving motor function.	1	Lim et al. 2008
2	**Triamcinolone acetonide with transcutaneous electrical nerve stimulation** may not have a difference in efficacy compared to **transcutaneous electrical nerve stimulation** for improving motor function.	1	Lakse et al. 2009

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Triamcinolone acetonide** may not have a difference in efficacy compared to **botulinum toxin** for improving spasticity.	1	Lim et al. 2008
2	**Triamcinolone acetonide** may not have a difference in efficacy compared to **conventional therapy** for improving spasticity.	1	Baykal et al. 2013
2	**Triamcinolone acetonide with transcutaneous electrical nerve stimulation** may not have a difference in efficacy compared to **transcutaneous electrical nerve stimulation** for improving spasticity.	1	Lakse et al. 2009

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Triamcinolone acetonide** may produce greater improvements in range of motion than **conventional therapy or placebo.**	2	Baykal et al. 2013; Rah et al. 2012
2	**Triamcinolone acetonide with transcutaneous electrical nerve stimulation** may produce greater improvements in range of motion than **transcutaneous electrical nerve stimulation.**	1	Lakse et al. 2009
1b	**Triamcinolone acetonide** may not have a difference in efficacy compared to **botulinum toxin** for improving range of motion.	1	Lim et al. 2008
2	**Triamcinolone acetonide** may not have a difference in efficacy compared to **a suprascapular nerve block** for improving range of motion.	1	Yasar et al. 2011

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Triamcinolone acetonide** may not have a difference in efficacy compared to **conventional therapy** for improving activities of daily living.	1	Baykal et al. 2013
2	**Triamcinolone acetonide with transcutaneous electrical nerve stimulation** may not have a difference in efficacy compared to **transcutaneous electrical nerve stimulation** for improving activities of daily living.	1	Lakse et al. 2009

MUSCLE STRENGTH			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Triamcinolone acetonide** may produce greater improvements in muscle strength than **placebo.**	1	Rah et al. 2012

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Triamcinolone acetonide with transcutaneous electrical nerve stimulation** may produce greater reductions in pain than **transcutaneous electrical nerve stimulation.**	1	Lakse et al. 2009
1b	There is conflicting evidence about the effect of **Triamcinolone acetonide** to reduce pain when compared to **conventional therapy or placebo**.	3	Baykal et al. 2013; Snels et al. 2000; Rah et al. 2012
1b	**Triamcinolone acetonide** may not have a difference in efficacy compared to **botulinum toxin** for reducing pain.	1	Lim et al. 2008
2	**Triamcinolone acetonide** may not have a difference in efficacy compared to **suprascapular nerve block** for reducing pain.	1	Yasar et al. 2011

Key Points

The literature is mixed regarding the effectiveness of triamcinolone acetonide alone or in combination with transcutaneous electrical stimulation for shoulder hemiplegia following stroke.

Hyaluronic Acid

Adopted from https://www.eastcoastphysio.co.uk/our-services/joint-injections-cortisone-ostenil-plus-injections/

Hyaluronic acid injections are an alternative to intra-articular steroid injections which interfere with cartilage metabolism and may contribute to destruction of the joint through inducing apoptosis and arthropathy of chondrocytes (Gaffney et al. 1995; Gottlieb & Riskin 1980; Pelletier et al. 1989; Steinberg & Sledge 1983; Nakazawa et al. 2002). Hyaluronic acid is believed to have an anti-inflammatory effect that may assist in regeneration of cartilage as it contains components of cartilage matrix, including glycosaminoglycan and proteoglycan (Hulmes et al. 2004; Kitoh et al. 1992).

A total of 2 RCTs were found evaluating hyaluronic acid injections for the hemiplegic shoulder following stroke.

One RCT compared hyaluronic acid with conventional therapy to conventional therapy alone (Huang et al. 2016). One RCT compared hyaluronic acid to triamcinolone acetonide (Jang et al. 2016).

The methodological details and results of all 2 RCTs are presented in Table 13.

Table 13. RCTs Evaluating Hyaluronic Acid for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Hyaluronic acid vs conventional therapy		
Huang et al. (2016a) RCT (8) N_{start}=26 N_{end}=26 TPS=Subacute	E: Hyaluronic acid (2.5mL) + conventional rehabilitation C: No injection + conventional rehabilitation Duration: Hyaluronic acid (2.5mL) 1d/wk for 3wk + conventional rehab	• Visual Analogue Scale (+exp) • Range of Motion (-) • Modified Ashworth Scale (-) • Fugl-Meyer Assessment (-)
Hyaluronic acid vs triamcinolone acetonide		
Jang et al. (2016) RCT (5) N_{start}=39 N_{end}=31 TPS=Subacute	E: Hyaluronic acid (2mL) C: Triamcinolone acetonide (40mg) Duration: Hyaluronic acid (2mL) 3d/wk for 4wk	• Wong-Baker Scale for pain (-) • Range of Motion (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Hyaluronic Acid

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Hyaluronic acid injections** may not have a difference in efficacy compared to **conventional therapy** for improving motor function.	1	Huang et al. 2016

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Hyaluronic acid** may not have a difference in efficacy compared to **conventional therapy** for improving spasticity.	1	Huang et al. 2016

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Hyaluronic acid** may not have a difference in efficacy compared to **conventional therapy** for improving range of motion.	1	Huang et al. 2016
2	**Hyaluronic acid** may not have a difference in efficacy compared to **triamcinolone acetonide** for improving range of motion.	1	Jang et al. 2016

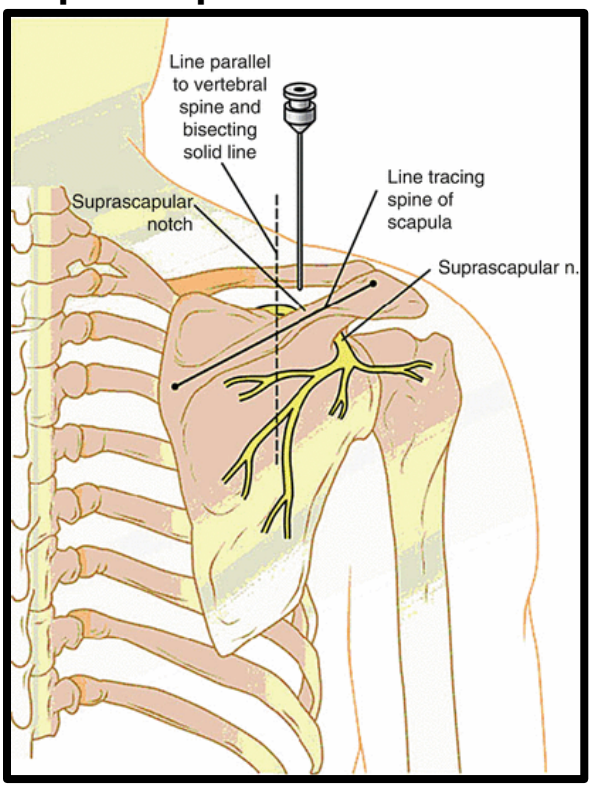
PAIN

LoE	Conclusion Statement	RCTs	References
1b	**Hyaluronic acid injections** may produce greater reduction in pain than **conventional therapy.**	1	Huang et al. 2016
2	**Hyaluronic acid injections** may not have a difference in efficacy compared to **triamcinolone acetonide** for reducing pain.	1	Jang et al. 2016

Key Points

The literature is mixed regarding the effectiveness of hyaluronic acid injections for reducing hemiplegic shoulder pain, while hyaluronic acid injections are likely not effective for improving motor function, range of motion, or spasticity in the hemiplegic shoulder following stroke.

Suprascapular Nerve Block



Adopted from: https://radiologykey.com/suprascapular-nerve-block-2/

The suprascapular nerve supplies the majority of sensory innervation to the glenohumeral (shoulder) joint, and thus suprascapular nerve block may provide relief from hemiplegic shoulder pain (Ritchie et al. 1997). A suprascapular nerve block is administered by injection of an anesthetic into the supraspinatus fossa of the shoulder (Al-Kaisy et al. 1998; Brown et al. 1993).

A total of 4 RCTs were found evaluating suprascapular nerve block for the hemiplegic shoulder following stroke.

One RCT compared blinded suprascapular nerve block to stimulator suprascapular nerve block (Kulcu et al. 2016). One RCT compared suprascapular nerve block to placebo (Adey-Wakeling et al. 2013). One RCT compared suprascapular nerve block to a steroid injection (Yasar et al. 2011). One RCT compared suprascapular nerve block to ultrasound therapy (Boonsong et al. 2009)

The methodological details and results of all 4 RCTs are presented in Table 14.

Table 14. RCTs Evaluating Suprascapular Nerve Block for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Blinded vs stimulator administration of suprascapular nerve block		
Kulcu et al. (2016) RCT (6) N_{start}=26 N_{end}=26 TPS= Chronic	E: Blinded suprascapular nerve block C: Stimulator suprascapular nerve block Duration: Single dose	• Visual Analogue Scale (-) • Range of Motion (-)
Suprascapular nerve block vs placebo		
Adey-Wakeling et al. (2013) RCT (9) N_{start}=64 N_{end}=57 TPS=Subacute	E: Suprascapular nerve block + routine therapy C: Saline + routine therapy Duration: Single Injection of Suprascapular nerve block +routine therapy	• Visual Analogue Scale (+exp) • Modified Rankin Scale (-) • Croft Disability Index (-)
Suprascapular nerve block vs ultrasound therapy or steroid injection		
Yasar et al. (2011) RCT (5) N_{start}=26 N_{end}=26 TPS=Chronic	E1: Suprascapular nerve block E2: Steroid Duration: Single Injection of Suprascapular nerve block (40mg)	• Visual Analogue Scale (-) • Range of Motion (-)
Boonsong et al. (2009) RCT (4) N_{start}=10 N_{end}=10 TPS=Chronic	E1: Suprascapular nerve block E2: Ultrasound therapy Duration: Suprascapular nerve block 2d/wk for 4wk	• Visual Analogue Scale (+exp) • Range of Motion (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Suprascapular Nerve Block

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Blinded suprascapular nerve block** may not have a difference in efficacy compared to **stimulator suprascapular nerve block** for improving range of motion.	1	Kulcu et al. 2016
2	**Suprascapular nerve block** may not have a difference in efficacy compared to **steroid injections or ultrasound therapy** for improving range of motion.	2	Yasar et al. 2011; Boonsong et al. 2009

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Suprascapular nerve block** may not have a difference in efficacy compared to **placebo** for improving activities of daily living.	1	Adey-Wakeling et al. 2013

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Suprascapular nerve block** may produce greater reductions in pain than **placebo.**	1	Adey-Wakeling et al. 2013
2	There is conflicting evidence about the effect of **suprascapular nerve block** in reducing pain when compared to **steroid injections or ultrasound therapy**.	2	Yasar et al. 2011; Boonsong et al. 2009
1b	**Blinded suprascapular nerve block** may not have a difference in efficacy compared to **stimulator suprascapular nerve block** for reducing pain.	1	Kulcu et al. 2016

STROKE SEVERITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Suprascapular nerve block** may not have a difference in efficacy for improving activities of daily living when compared to **placebo**.	1	Adey-Wakeling et al. 2013

Key Points

The literature is mixed regarding the effectiveness of suprascapular nerve block for reducing hemiplegic shoulder pain, while suprascapular nerve block is likely not beneficial for improving motor function, range of motion, or activities of daily living following stroke.

Segmental Neuromyotherapy

Segmental neuromyotherapy (SNMT) is a recently developed method that involves administration of a local anaesthetic injection into the dermatome to block the posterior branch of the dorsal spine nerve along the para-spinal muscles that are involved (Ratmansky et al. 2012). Additional local anaesthetic is injected peripherally near the foci of irritation in local soft tissue into taut bands and trigger points through a needling and infiltration technique (Ratmansky et al. 2012). Heat and transcutaneous electrical nerve stimulation are then used to achieve complete muscular relaxation (Ratmansky et al. 2012).

One RCT was found evaluating segmental neuromyotherapy for the hemiplegic shoulder, in which segmental neuromyotherapy was compared to conventional therapy (Ratmansky et al. 2012).

The methodological details and results of the RCT are presented in Table 15.

Table 15. RCTs Evaluating Segmental Neuromyotherapy for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Ratmansky et al. (2012) RCT (7) N_{start}=24 N_{end}=24 TPS=Subacute	E: Segmental neuromyotherapy + Standard therapy including oral pain medication C: Standard therapy including oral pain medication Duration: 45min/d, 3d/wk for 4wk	• Hand Behind Neck Test for Pain (-) • Neer Test for Pain (+exp) • Visual Analogue Scale (-) • Fugl-Meyer Assessment (+exp) • Modified Ashworth Scale (-) • Algometry Test for Pain (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Segmental Neuromyotherapy

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Segmental neuromyotherapy** may produce greater improvements in motor function than **conventional therapy.**	1	Ratmansky et al. 2012

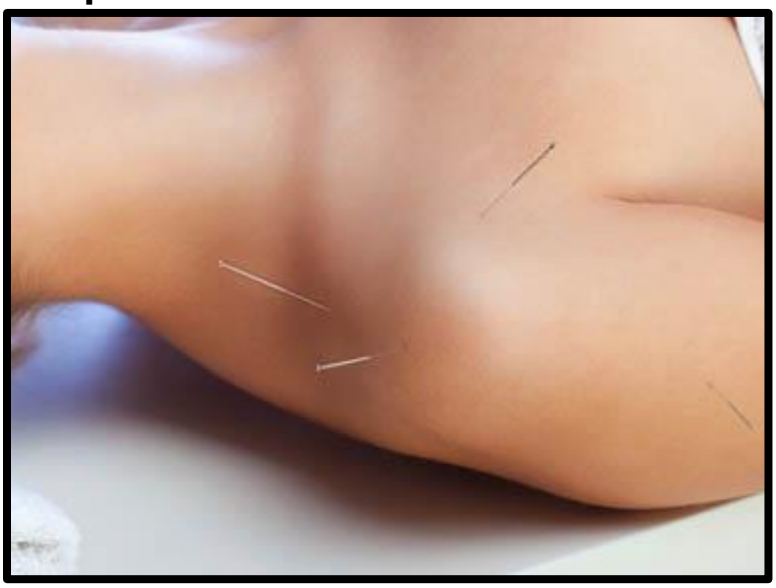
SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
2	**Segmental neuromyotherapy** may not have a difference in efficacy compared to **conventional therapy** for improving spasticity.	1	Ratmansky et al. 2012

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	There is conflicting evidence about the effect of **segmental neuromyotherapy** for reducing pain when compared to **conventional therapy**.	1	Ratmansky et al. 2012

Key Points

Segmental neuromyotherapy is likely beneficial for improving motor function, and possibly hemiplegic shoulder pain, but likely not beneficial for improving spasticity following stroke.

Acupuncture



Adopted from https://www.healthcmi.com/Acupuncture-Continuing-Education-News/1515-acupuncture-reduces-shoulder-hand-syndrome-pain

The use of acupuncture has recently gained attention as an adjunct to stroke rehabilitation in Western countries even though acupuncture has been a primary treatment method in China for about 2000 years (Baldry, 2005). In China, acupuncture is considered to be a common, efficient, and safe form of treatment used to improve motor function, sensation, and verbal communication following a stroke (Wu et al., 2002). According to Rabinstein and Shulman (2003), acupuncture involves stimulation of defined anatomic locations on the skin by a variety of techniques, the most common being stimulation with metallic needles that are either manually manipulated or that serve as electrodes conducting electrical currents. There is a range of possible acupuncture mechanisms that may contribute to the improvements experienced by stroke patients. For example, acupuncture may stimulate the release of neurotransmitters (Han & Terenius, 1982) and have an effect on the deep structure of the brain (Wu et al. 2002). Lo et al. (2005) established that acupuncture, when applied for at least 10 minutes, led to long-lasting changes in cortical excitability and plasticity even after the needle stimulus was removed. With respect to stroke rehabilitation, the benefit of acupuncture has been evaluated most frequently for pain relief and recovery from hemiparesis.

A total of 4 RCTs were found evaluating acupuncture for the hemiplegic shoulder following stroke. Two RCTs compared acupuncture to conventional therapy (Mendigutia-Gomez et al. 2016; Zhao et al. 2015). One RCT compared acupuncture with herbal therapy to acupuncture (Seo et al. 2013). One RCT compared superficial needling acupuncture with club swing to conventional therapy (Ni et al. 2017).

The methodological details and results of all 4 RCTs are presented in Table 16.

Table 16. RCTs Evaluating Acupuncture for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Acupuncture vs conventional therapy		
Mendigutia-Gomez et al. (2016) RCT (9) N_{start}=20 N_{end}=20 TPS=Chronic	E: Acupuncture C: Standard care Duration: 30min/d, 3d/wk for 4wk	• Pressure Pain Threshold (+exp) • Range of Motion (+exp) • Modified Ashworth Scale (+exp) • Shoulder Range of Motion (+exp)
Zhao et al. (2015) RCT (7) N_{start}=124 N_{end}=105 TPS=Chronic	E: Acupuncture C: Standard care Duration: 30min/d, 5d/wk for 2wk	• Visual Analogue Scale (+exp) • Range of motion (+exp) • Barthel Index (-)
Acupuncture with herbal therapy vs acupuncture		
Seo et al. (2013) RCT (7) N_{start}=29 N_{end}=26 TPS=Subacute	E: Acupuncture, herbal C: Acupuncture, standard Duration: 45min/d, 3d/wk for 2wk	• Numerical Rating Scale (+exp) • Passive Range of Motion (-) • Fugl-Meyer Assessment (-)
Superficial needling acupuncture with club swing vs conventional therapy		
Ni et al. (2017) RCT (5) N_{Start}=180 N_{End}=176 TPS= Chronic	E: Superficial needling acupuncture plus club swing + conventional therapy C: Conventional therapy Duration: 1 to 2 times/d for 60d	• Visual Analogue Scale (+exp) • Functional Comprehensive Assessment (+exp) • Active Range of Motion: Shoulder flexion, extension, abduction, and internal rotation (+exp) • Active Range of Motion: External shoulder rotation (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Acupuncture

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture with herbal therapy** may produce greater improvements in motor function than **acupuncture.**	1	Seo et al. 2013

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture** may produce greater improvements in spasticity than **conventional therapy**	1	Mendigutia-Gomez et al. 2016

RANGE OF MOTION

LoE	Conclusion Statement	RCTs	References
1a	**Acupuncture** may produce greater improvements in range of motion than **conventional therapy**	2	Mendigutia-Gomez et al. 2016; Zhao et al. 2015
2	**Superficial needling acupuncture with club swing** may produce greater improvements in range of motion than **conventional therapy.**	1	Ni et al. 2017
1b	**Acupuncture with herbal therapy** may not have a difference in efficacy compared to **acupuncture** for improving range of motion.	1	Seo et al. 2013

ACTIVITIES OF DAILY LIVING

LoE	Conclusion Statement	RCTs	References
1b	**Acupuncture** may not have a difference in efficacy compared to **conventional therapy** for improving activities of daily living.	1	Zhao et al. 2015
2	**Superficial needling acupuncture with club swing** may produce greater improvements in activities of daily living than **conventional therapy.**	1	Ni et al. 2017

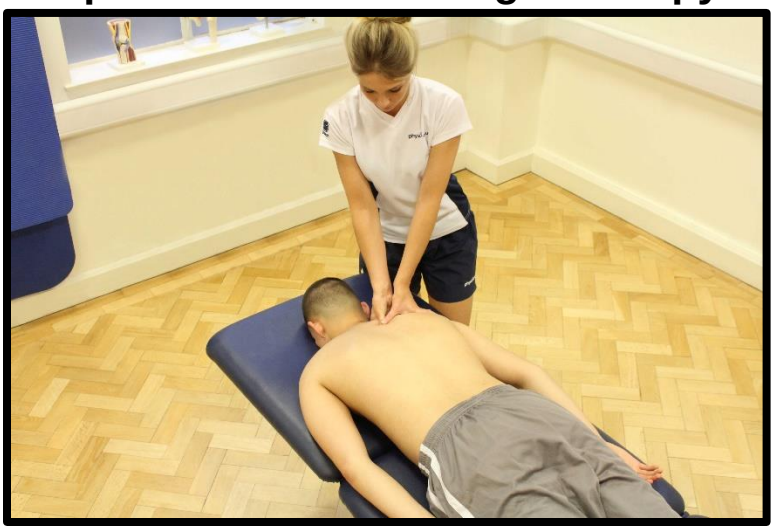
PAIN

LoE	Conclusion Statement	RCTs	References
1a	**Acupuncture** may produce greater reductions in pain than **conventional therapy.**	2	Mendigutia-Gomez et al. 2016; Zhao et al. 2015
1b	**Acupuncture with herbal therapy** may produce greater reductions in pain than **acupuncture.**	1	Seo et al. 2013
2	**Superficial needling acupuncture with club swing** may produce greater reductions in pain than **conventional therapy.**	1	Ni et al. 2017

Key Points

Acupuncture may beneficial for improving pain in the hemiplegic shoulder after stroke.

Acupressure and Massage Therapy



Adopted from https://www.physio.co.uk/treatments/physiotherapy/manual-therapy/acupressure.php

Acupressure is a form of massage in traditional Chinese medicine in which movement of qi or life energy is encouraged through various the channels or meridians inside the body (Chen et al. 2007). Acupressure makes use of the same meridians and acupoints as acupuncture with the same goal of encouraging energy flow throughout the body (Chen et al. 2007; Di et al. 2017).

Massage is the practice of applying structured pressure, tension, motion or vibration — manually or with mechanical aids — to the soft tissues of the body, including: muscles, connective tissue, tendons, ligaments, joints and lymphatic vessels, to achieve a beneficial response (Holland & Pokorny, 2001). The benefits of massage therapy are suggested to be increased blood flow, relief of muscle spasms and release of β-endorphins (Wei et al. 2017). One of the more common forms of massage therapy is the traditional Chinese massage therapy also known as Tui Na (Yang et al. 2017).

A total of 3 RCTs were found evaluating acupressure or massage therapy for the hemiplegic shoulder following stroke. One RCT compared acupuncture with massage therapy to Bobath therapy (Li et al. 2012). One RCT compared acupressure with essential oils to dry acupressure (Shin & Lee 2007). One RCT compared slow-stroke back massage to conventional therapy (Mok & Woo 2004).

The methodological details and results of all 3 RCTs are presented in Table 17.

Table 17. RCTs Evaluating Acupressure and Massage Therapy for the Hemiplegic Shoulder

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Acupuncture with massage therapy vs bobath therapy		
Li et al. (2012) RCT (6) N_{start}=120 N_{end}=102 TPS=Chronic	E: Acupuncture + Massage C: Bobath therapy Duration: 45min/d, 5d/wk for 4wk	• Numeric Pain Rating Scale (+exp) • Fugl-Meyer Assessment (+exp) • Shoulder-Hand Syndrome (+exp) • Modified Rankin Scale (+exp)
Essential oils vs dry acupressure		
Shin & Lee (2007) RCT (6) N_{start}=30 N_{end}=27 TPS=Chronic	E: Acupressure, essential oils C: Acupressure, dry Duration: 20min/d (2x/d), for 2wk	• Verbal Pain Rating System (+exp) • Motor Power (-)
Slow-stroke back massage vs conventional therapy		
Mok & Woo (2004) RCT (5) N_{start}=102 N_{end}=98 TPS=Chronic	E: Slow-stroke back massage C: Standard care Duration: Not Specified	• Visual Analogue Scale (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Acupressure and Massage Therapy

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture with massage therapy** may produce greater improvements in motor function than **Bobath therapy**.	1	Li et al. 2012

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture with massage therapy** may produce greater improvements in pain than **Bobath therapy.**	1	Li et al. 2012
1b	**Acupressure with essential oils** may produce greater improvements in pain than **dry acupressure.**	1	Shin & Lee 2007
2	**Slow-stroke back massage** may produce greater improvements in pain than **conventional therapy**.	1	Mok & Woo 2004

MUSCLE STRENGTH

LoE	Conclusion Statement	RCTs	References
1b	**Acupressure with essential oils** may not have a difference in efficacy for improving muscle strength when compared to **dry acupressure.**	1	Shin & Lee 2007

STROKE SEVERITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Acupuncture with massage therapy** may produce greater improvements in stroke severity than **Bobath therapy**.	1	Li et al. 2012

Key Points

Acupressure and massage therapy are likely beneficial for motor function and hemiplegic shoulder pain following stroke.

Complex Regional Pain Syndrome

Stages and symptoms of Complex Regional Pain Syndrome (CRPS)

CRPS can be categorized as one of two forms:

1. Type I, also referred to as shoulder-hand syndrome or reflex sympathetic dystrophy, is more common and associated with hemiplegia.
2. Type II, also referred to as causalgia, is less common and associated with traumatic injury.

CRPS is characterized by numerous peripheral and central nervous system changes in the absence of obvious nerve injury (Table 18). Peripheral changes include vasomotor tone with associated hand pain and swelling, exquisite hyperaesthesia, protective immobility, trophic skin changes, and vasomotor instability of the involved upper extremity (Moseley, 2004, 2006). Central changes include a disruption of sensory cortical processing, disinhibition of the motor cortex, and disrupted body schema (Moseley, 2004, 2006).

Table 18. Stages and symptoms of CRPS (Adopted from Iwata et al. 2002)

Stage	Symptoms
1	• Persistent pain, described as burning or aching • Extremity is edematous, warm, and hyperesthetic • Pain is aggravated by movement
2	• Early dystrophic changes in the limb • Atrophy of the muscle and skin • Vasospasm with hyperhidrosis
3	• Soft-tissue dystrophy • Contractures that produce frozen shoulder • Pain and vasomotor changes are infrequent

Initially, CRPS generally presents with pain in the shoulder followed by a painful, edematous hand and wrist (Davis et al.1977). There is frequently decreased range of motion at the shoulder and hand, while the elbow joint is spared. Passive flexion of the wrist and hand joints is painful and limited due to edema over the dorsum of the fingers. As time progresses, the extensor tendons become elevated and the collateral ligaments shorten. If untreated, it has long been thought that the condition eventually progresses to a dry, cold, bluish, and atrophied hand. However, experience would suggest that in most cases the pain and edema subside spontaneously after a few weeks.

CRPS is not unique to patients recovering from stroke and is prevalent among patients with head injury, spinal cord injury, and even mild injury to the extremities. Typically, patients with post-stroke CRPS present with pain, hyperalgesia, joint stiffness and swelling, and autonomic abnormalities. While recovery is largely spontaneous, CRPS that persists for more than six months is often difficult to treat.

Pathophysiology of CRPS

The etiology of CRPS is unknown, but theoretical peripheral and central aetiologies have been proposed. Peripheral etiological theories hypothesize a role for trauma to the peripheral nerves. One theory postulates ephaptic conduction between efferent sympathetic nerves and afferent

somatic nerves, with the latter depolarization being perceived as pain. Central etiological theories hypothesize a disruption of autonomic nervous control from higher central nervous system centres. One theory postulate that such a disruption directly affects the internuncial pool of the spinal cord, leading to decreased inhibition of the sympathetic neurons of the lateral horn. Pain, either from contractures or subluxation, may stimulate the internuncial pool of the spinal cord and result in an abnormal sympathetic response. CRPS has often been regarded as a form of sympathetically-mediated pain involving the hemiplegic upper extremity, but a link between the abnormal sympathetic nervous system and pain has yet to be proven.

CRPS has also been proposed to be a result of paresis following stroke, mediated by disruption of the balance between intracellular and extracellular fluid (Iwata et al. 2002). Three possible mechanisms were suggested: (1) increased capillary blood pressure, caused by decreased peripheral venous return and lymph flow; (2) decreased colloidal osmotic pressure in the early stages of stroke, due to an acute phase response; and (3) enhanced permeability of capillary walls, which may result from synovial inflammation, brought about by rough management of the affected arm and hand.

In a systematic review, Geurts et al. (2000) identified five etiological studies and six therapeutic studies regarding post-stroke CRPS. The authors found that the shoulder was involved in only half of the cases, while all of the cases were characterized by painful swelling of the wrist and hand, thereby suggesting a “wrist-hand syndrome” in the other half of cases. Furthermore, they noted that CRPS hand edema was not a lymphoedema and usually coincided with increased arterial blood flow.

Diagnosis of CRPS

Several approaches to diagnose CRPS have been utilized, although no single test will identify all individuals with CRPS. Three sets of criteria are used routinely: (1) International Association for the Study of Pain (IASP) 1994 consensus criteria (Stanton-Hicks et al., 1995); (2) Bruehl’s (1999) criteria; and (3) Veldman’s (1993) criteria. The sensitivities and specificities of these sets of criteria range from 70% to 100% and from 36% to 94%, respectively. Common features among these criteria include: pain, allodynia, hyperalgesia, edema, changes in sweating, and limitations in range of motion. However, Tepperman et al. (1984) found that 25% of hemiplegic patients demonstrated evidence of CRPS in the involved upper extremity, but only 16.5% went on to develop the clinical syndrome.

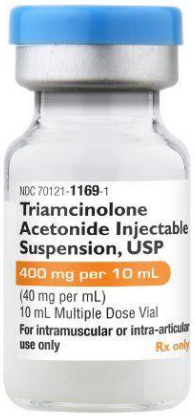
Routine radiographs of the involved upper extremity may demonstrate a patchy, periarticular demineralization (Sudek's atrophy) as early as three to six months after the onset of clinical signs. The most sensitive diagnostic test is the technetium diphosphonate bone scan, which demonstrates increased periarticular uptake in the affected upper extremity (mostly at the shoulder and wrist); bone scan abnormalities appear earlier than the X-ray changes. Temporary resolution of symptoms with sympathetic blockade is considered diagnostic. Despite potential difficulties with the technique in terms of diagnostic validity, the accuracy of these blocks has improved with image-guided injections (e.g. ultrasound). Thermography has failed to consistently diagnose CRPS and is not considered a valid test.

Kozin et al. (1981) suggested that clinical measurements such as grip strength, tenderness, and ring size were more accurate diagnostic indicator of CRPS. Similarly, Iwata et al. (2002) suggested that a ratio of the middle finger circumference (affected vs. unaffected) greater than 1.06 at four weeks post stroke was predictive of CRPS. It has been suggested by Quisel et al.

(2005) that although diagnosis through instrumentation and imaging is common, there is limited evidence that these techniques improve the diagnostic accuracy.

Management of complex regional pain syndrome

Steroids



Adopted from: https://inovatiqa.com/ap-rated-generic-kenalog-40r-corticosteroid-triamcinolone-acetonide-40-mg-ml-intramuscular-or-intra-articular-injection-multiple-dose-vial-10-ml.html

Prednisolone, methylprednisolone, triamcinolone are corticosteroid drugs which reduces inflammation in the body. Oral corticosteroids are considered to be the only anti-inflammatory dugs for which there is evidence supporting the effectiveness in complex regional pain syndrome (Harden et al. 2013). Early treatment of complex regional pain syndrome is considered to be essential for the potential near resolution of syndrome, thus preventing long-term pain, loss of function, and disability (Bianchi et al. 2006; Atalay et al. 2014).

A total of 5 RCTs were found evaluating steroids for complex regional pain syndrome following stroke.

One RCT compared oral prednisolone to an injection of pamidronate (Young et al. 2016). One RCT compared oral prednisolone to oral piroxicam (Kalita et al. 2006).

One RCT compared oral prednisolone to no drug (Kalita et al. 2016). One RCT compared oral methylprednisolone to a placebo (Braus et al. 1994).

One RCT compared triamcinolone injections to lidocaine injections (Rah et al. 2012).

The methodological details and results of all 5 RCTs are presented in Table 19.

Table 19. RCTs Evaluating Steroids for Complex Regional Pain Syndrome

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Prednisolone vs pamidronate or piroxicam		
Young et al. (2016) RCT (6) N_{start}=21 N_{end}=21 TPS=Chronic	E1: Oral Prednisolone (80mg) E2: Pamidronate injection (180mg) Duration: Prednisolone (80mg) per day for 2wk	• Visual Analogue Scale (+exp2) • Wrist Circumference (+exp1) • Finger Circumference (-)
Kalita et al. (2006) RCT (7) N_{start}=60 N_{end}=60 TPS=Chronic	E: Oral Prednisolone (40mg) C: Oral Piroxicam (20mg) Duration: Prednisolone (40mg) per day for 4wk	• Complex Regional Pain Syndrome Scale (+exp) • Barthel Index (-)
Prednisolone or methylprednisolone vs placebo or no drug		
Kalita et al. (2016) RCT (5) N_{start}=52 N_{end}=50 TPS=Chronic	E: Oral Prednisolone (10mg) C: No drug Duration: Prednisolone (10mg) per day for 4wk	• Visual Analogue Scale (+exp) • Complex Regional Pain Syndrome Scale (+exp) • Modified Rankin Scale (-) • Barthel Index (-)

Braus et al. (1994)
RCT (5)
N_{start}=36
N_{end}=31
TPS=Subacute
	E: Oral Methylprednisolone (8mg)
	C: Placebo
	Duration: Methylprednisone (8mg) 4x/d for 2wk
		• Shoulder-hand Syndrome Score:
		  ○ Pain reduction (+exp)
		  ○ Range of Motion (+exp)

Triamcinolone vs lidocaine		
Rah et al. (2012) RCT (6) N_{start}=60 N_{end}=58 TPS=Chronic	E: Triamcinolone injection (40mg) C: Lidocaine injection Duration: Triamcinolone (40mg) per day for 3wk	• Visual Analogue Scale (+exp) • Modified Barthel Index (-) • Shoulder Disability Questionnaire (+exp) • Active shoulder flexion (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Steroids for Complex Regional Pain Syndrome

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Triamcinolone** may produce greater improvements in motor function than **lidocaine**	1	Rah et al. 2012

RANGE OF MOTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Triamcinolone** may not have a difference in efficacy compared to **lidocaine** for improving range of motion.	1	Rah et al., 2012
2	**Methylprednisolone** may produce greater improvements in range of motion than **placebo.**	1	Braus et al. 1994

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Prednisolone** may not have a difference in efficacy compared to **pamidronate** for improving activities of daily living.	1	Kalita et al. 2006
1b	**Triamcinolone** may not have a difference in efficacy compared to **lidocaine** for improving activities of daily living.	1	Rah et al., 2012
2	**Prednisolone** may not have a difference in efficacy compared to **no drug** for improving activities of daily living.	1	Kalita et al. 2016

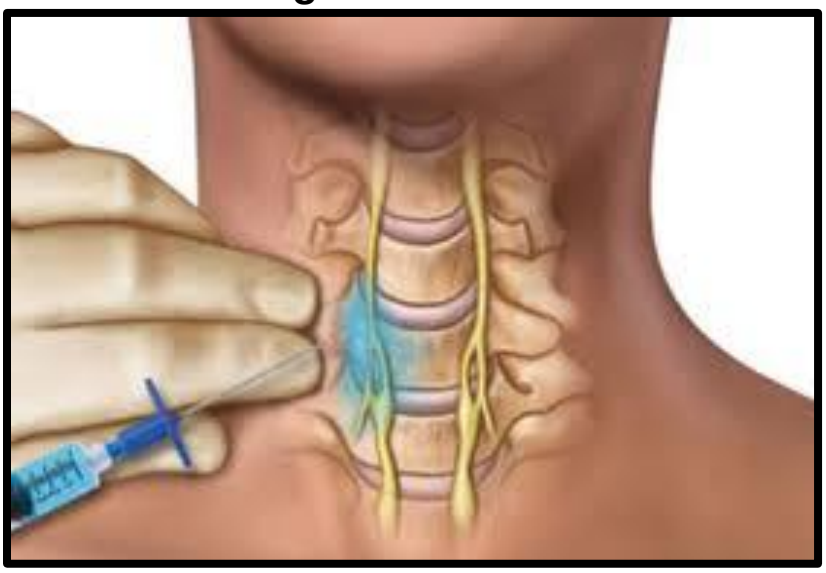
PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Prednisolone** may produce greater improvements in pain than **pamidronate or piroxicam.**	2	Young et al. 2016; Kalita et al. 2006
1b	**Triamcinolone** may produce greater improvements in pain than **lidocaine.**	1	Rah et al. 2012
2	**Prednisolone or methylprednisolone** may produce greater improvements in pain than **placebo or no drug**.	2	Kalita et al. 2016; Braus et al. 1994

Key Points

Steroids are likely beneficial for improving motor function and pain following a stroke.

Steroids may not be beneficial for improving activities of daily living.

Nerve Block Agents



Adopted from: http://www.drparthshah.in/Treatments.php

Nerve blocks are a locally acting treatment for spasticity that have the advantage of reducing harmful spasticity in one area, while preserving useful spasticity in another area (Kirazli et al. 1998). Depending on the pharmacological agent used, the temporary effect of a nerve block reverses within 1–12 h (Gross et al. 2014). With respect to pain, these nerve blocks are used with the intention of pharmacologically inhibiting pain reception and/or signal transduction.

One RCT was found examining nerve block agents for treatment of complex regional pain syndrome (Yoo et al., 2012). This study examined lidocaine injections at the stellate ganglion guided by ultrasound, or injected 'blind' using anatomical markers.

The methodological details and results of the single RCT are presented in Table 20.

Table 20. RCTs Evaluating Nerve Block for Complex Regional Pain Syndrome

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Yoo et al. (2012) RCT (6) N_{start}=42 N_{end}=38 TPS=Subacute	E: Stellate ganglion block, ultrasound guided C: Stellate ganglion block, blind Duration: 30min/d, 1d/wk for 2wk	• Visual Analogue Scale (+exp) • Complex Regional Pain Syndrome Scale (-) • Swelling (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Nerve Block for Complex Regional Pain Syndrome

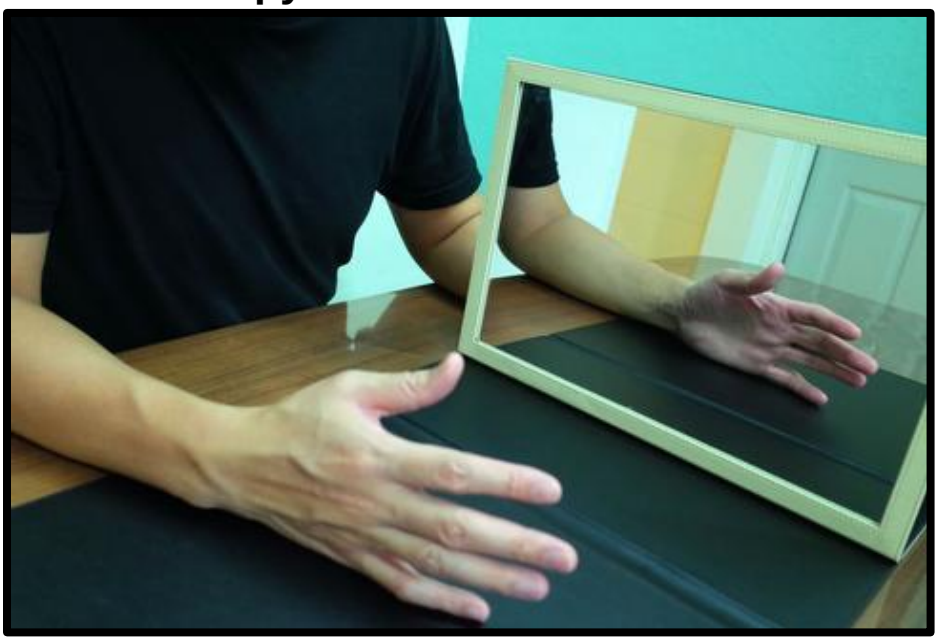
PAIN

LoE	Conclusion Statement	RCTs	References
1b	**Stellate ganglion block guided by ultrasound** may not have a difference in efficacy when compared to **stellate ganglion block with no guide** for improving pain.	1	Yoo et al., 2012

Key Points

Ultrasound guided injection for nerve block agents may not be beneficial for improving complex regional pain syndrome.

Mirror Therapy



Adopted from: https://tbirehabilitation.wordpress.com/2018/01/16/web-site-benefits-of-mirror-therapy-exercise-for-stroke-patients-mirrortherapy-com/

In mirror therapy, a mirror is placed beside the unaffected limb, blocking view of the affected limb and creating an illusion of two limbs as if they are both functioning normally. Mirror therapy functions through a process known as mirror visual feedback wherein the movement of one limb is perceived as movement from the other limb (Deconinck et al. 2015). In the brain, mirror therapy is thought to induce neuroplastic changes that promote recovery by increasing excitability of the ipsilateral motor cortex which projects to the paretic limb (Deconinck et al. 2015). This therapy can be used to promote motor recovery, but it has also been successful in the treatment of neuropathic pain (Wittkopf & Johnson, 2017). Although the exact cause of complex regional pain syndrome is not yet identified, it is believed that the experience of pain results from improper and incongruent signal transmission (Tichelaar et al., 2007). By substituting compromised proprioceptive input with visual feedback of the limb, a patient can potentially re-wire the somatosensory cortex and its pertinent connections to correct the malfunction of the nervous system.

3 RCTs were found that looked at mirror therapy for the treatment of complex regional pain syndrome (Purvane Vural et al., 2016; Cacchio et al., 2009a; Cacchio et al., 2009b). All 3 RCTs looked at mirror therapy against a sham condition, or standard care (Purvane Vural et al., 2016). One also compared mirror therapy against mental practice (Cacchio et al., 2009b).

The methodological details and results of the 3 RCTs are presented in Table 21.

Table 21. RCTs Evaluating Mirror for Complex Regional Pain Syndrome

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Pervane Vural et al. (2016) RCT (7) N_{start}=30 N_{end}=30 TPS=Chronic	E: Mirror therapy C: Standard care Duration: 2-4hr/d, 5d/wk for 4wk	• Visual Analogue Scale (+exp) • Functional Independence Measure (+exp) • Fugl-Meyer Assessment (+exp) • Brunnstrom Recovery Stages (+exp) • Modified Ashworth Scale (-)
Cacchio et al. (2009a) RCT (7) N_{start}=48 N_{end}=48 TPS=Chronic	E: Mirror therapy C: Covered mirror therapy Duration: 1hr/d, 5d/wk for 6wk	• Visual Analogue Scale (+exp) • Wolf Motor Function Test (+exp) • Motor Activity Log (+exp)
Cacchio et al. (2009b) RCT (5) N_{start}=24 N_{end}=22 TPS=Chronic	E: Mirror therapy C1: Covered mirror therapy C2: Mental practice Duration: 1hr/d, 5d/wk for 6wk	• Visual Analogue Scale (+exp) • Wolf Motor Function Test (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Mirror Therapy

MOTOR FUNCTION			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Mirror therapy** may produce greater improvements in motor function than **conventional therapy or a sham condition**.	3	**Purvane Vural et al., 2016; Cacchio et al., 2009a; Cacchio et al., 2009b**

SPASTICITY			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Mirror therapy** may not have a difference in efficacy when compared to **conventional therapy or a sham condition** for improving spasticity.	1	**Purvane Vural et al., 2016**

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Mirror therapy** may produce greater improvements in pain than **conventional therapy or a sham condition**.	3	**Purvane Vural et al., 2016; Cacchio et al., 2009a; Cacchio et al., 2009b**

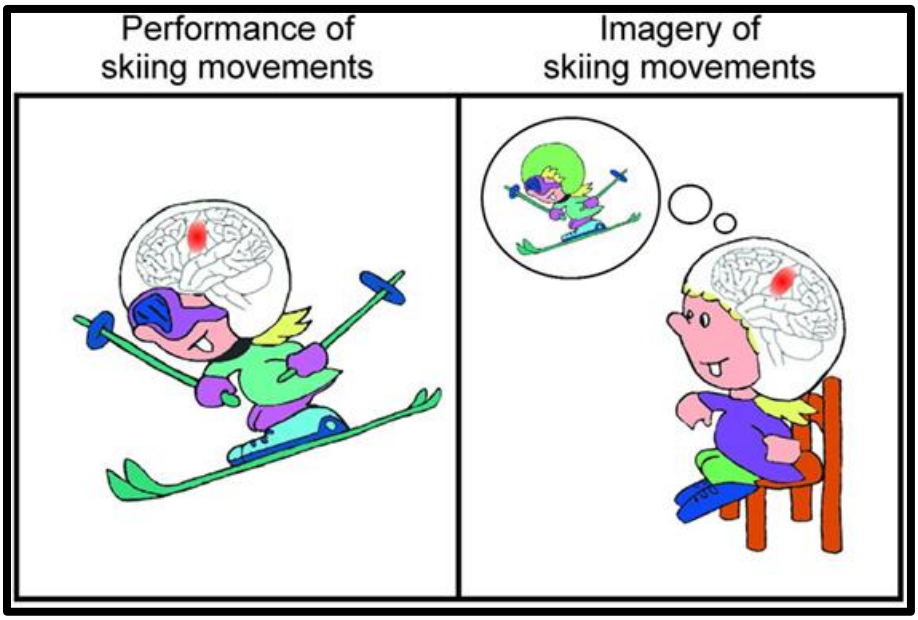
ACTIVITIES OF DAILY LIVING

LoE	Conclusion Statement	RCTs	References
1a	**Mirror therapy** may produce greater improvements in activities of daily living than **conventional therapy or a sham condition**.	2	**Purvane Vural et al., 2016; Cacchio et al., 2009a**

Key Points

Mirror therapy may be beneficial for improving motor function, pain and activities of daily living in individuals affected by complex regional pain syndrome but may not be beneficial for improving spasticity.

Mental Practice



Adopted from: https://www.ucbmsh.com/motor-imagery-for-improvement-of-gait-in-stroke-patient/

Mental practice as the name suggests, involves cognitively rehearsing a specific task by repetitively imagining oneself performing the precise movements involved in the task in the absence of performing the physical movement (Page et al. 2014). Mental practice is speculated to be effective because of its ability to use the same motor schema as when physically practicing the same task through the activation of similar neural regions and networks during mental practice (Page et al. 2014). The use of mental practice was adapted from the field of sports psychology where the technique has been shown to improve athletic performance, when used as an adjunct to standard training methods (Page et al. 2014). The technique is believed to be advantageous for individuals living with complex regional pain syndrome because actual movement of the limb often causes serious pain. Mental rehearsal would, in theory, promote neuroplastic changes without causing the affected individual any discomfort (Moseley, 2004). Mental practice can be used to supplement conventional therapy and can be used at any stage of recovery.

2 RCTs were found that examine mental practice for the treatment of complex regional pain syndrome. Both RCTs looked at motor imagery against standard care (Moseley 2006; Moseley 2004).

The methodological details and results of the 2 RCTs are presented in Table 22.

Table 22. RCTs Evaluating Mental Practice for Complex Regional Pain Syndrome

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Moseley (2006) RCT (6) N_{start}=51 N_{end}=47 TPS=Chronic	E: Motor imagery C: Standard care Duration: 45min/d, 3d/wk for 10wk	• Reduction of Pain (+exp)
Moseley (2004) RCT (7) N_{start}=13 N_{end}=13 TPS=Chronic	E: Motor imagery C: Standard care Duration: 45min/d, 3d/wk for 12wk	• Reduction of Pain (+exp)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Mental Practice

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1a	**Motor imagery** may produce greater improvements in pain than **standard care.**	2	Moseley, 2006; Moseley 2004

Key Points

Mental practice may be beneficial for reducing pain in individuals with complex regional pain syndrome.

Aerobic Exercise

Adopted from https://www.strokenetworkseo.ca/sites/strokenetworkseo.ca/files/osn-post-stroke-community-based-exercise-guidelines-2016-final.pdf

A large variety of physiotherapeutic therapies are often used for the treatment of complex regional pain syndrome, such as range of motion exercises and continuous passive movement among others (Topcuoglu et al. 2015; Geurts et al. 2000). While there is a lack of evidence regarding the effectiveness of aerobic exercise for complex regional pain syndrome, it is commonly included in conventional rehabilitation programs to improve motor function after stroke and is recommended in best practice and clinical guidelines (Gezer et al. 2018). Aerobic exercise can be defined as a variety of exercises that increase the demand for oxygen, typically over a duration of 20 minutes, and which elevate the heart rate to between 55% and 85% of estimated maximum heart rate (Executive Health's Good Health Report, 1998). Aerobic exercise has been demonstrated to improve aerobic fitness, as well as walking speed and endurance (Pang et al. 2013).

One RCT was found evaluating aerobic exercise for complex regional pain syndrome, in which aerobic exercise was compared to conventional therapy following stroke (Topcuoglu et al. 2015).

The methodological details and results of the RCT are presented in Table 23.

Table 23. RCTs Evaluating Aerobic Exercise for Complex Regional Pain Syndrome

Authors (Year) Study Design (PEDro Score) Sample Size$_{start}$ Sample Size$_{end}$ Time post stroke category	Interventions Duration: Session length, frequency per week for total number of weeks	Outcome Measures Result (direction of effect)
Topcuoglu et al. (2015) RCT (6) N_{start}=40 N_{end}=37 TPS=Subacute	E: Aerobic exercise C: Conventional therapy Duration: 30min/d, 3d/wk for 4wk	• Clinical Regional Pain Syndrome (+exp) • Visual Analogue Scale (+exp) • Functional Independence Measure (-)

Abbreviations and table notes: C=control group; D=days; E=experimental group; H=hours; Min=minutes; RCT=randomized controlled trial; TPS=time post stroke category (Acute: less than 30 days, Subacute: more than 1 month but less than 6 months, Chronic: over 6 months); Wk=weeks.
+exp indicates a statistically significant between groups difference at α=0.05 in favour of the experimental group
+exp$_2$ indicates a statistically significant between groups difference at α=0.05 in favour of the second experimental group
+con indicates a statistically significant between groups difference at α=0.05 in favour of the control group
- indicates no statistically significant between groups differences at α=0.05

Conclusions about Aerobic Exercise for Complex Regional Pain Syndrome

ACTIVITIES OF DAILY LIVING			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Aerobic exercise** may not have a difference in efficacy compared to **conventional therapy** for improving activities of daily living.	1	Topcuoglu et al. 2015

PAIN			
LoE	**Conclusion Statement**	**RCTs**	**References**
1b	**Aerobic exercise** may produce greater improvements in pain than **conventional therapy.**	1	Topcuoglu et al. 2015

Key Points

Aerobic exercise is likely beneficial for improving pain but may not be effective for improving activities of daily living following stroke.

References

Ada, L., Foongchomcheay, A., Langhammer, B., Preston, E., Stanton, R., Paul, S., & Canning, C. (2016). Laptray and triangular sling are no more effective than a hemisling in preventing shoulder subluxation in those at risk early after stroke: A randomised trial.

Ada, L., Goddard, E., McCully, J., Stavrinos, T., & Bampton, J. (2005). Thirty minutes of positioning reduces the development of shoulder external rotation contracture after stroke: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, *86*(2), 230-234.

Adey-Wakeling, Z., Crotty, M., & Shanahan, E. M. (2013). Suprascapular nerve block for shoulder pain in the first year after stroke: a randomized controlled trial. *Stroke*, *44*(11), 3136-3141.

Aerobic exercise definitions. (1998, March*). Executive Health's Good Health Report, 34*(6), 7.

Al-Kaisy, A., McGuire, G., Chan, V. W. S., Bruin, G., Peng, P., Miniaci, A., & Perlas, A. (1998). Analgesic effect of interscalene block using low-dose bupivacaine for outpatient arthroscopic shoulder surgery. *Regional Anesthesia and Pain Medicine*, *23*(5), 469-473.

Allen, K., & Goodman, C. (2014). Using electrical stimulation: A guideline for allied health professionals. *Sydney: Sydney Local Health District and Royal Rehabilitation Center*.

Ancliffe, J. (1992). Strapping the shoulder in patients following a cerebrovascular accident (CVA): a pilot study. *Australian Journal of Physiotherapy*, *38*(1), 37-40.

Aoki, K. R., Ranoux, D., & Wissel, J. (2006). Using translational medicine to understand clinical differences between botulinum toxin formulations. *European journal of neurology*, *13*, 10-19.

Appel, C., Mayston, M., & Perry, L. (2011). Feasibility study of a randomized controlled trial protocol to examine clinical effectiveness of shoulder strapping in acute stroke patients. *Clinical rehabilitation*, *25*(9), 833-843.

Aras, M. D., Gokkaya, N. K. O., Comert, D., Kaya, A., & Cakci, A. (2004). Shoulder Pain In Hemiplegia: Results From A National Rehabilitation Hospital In Turkey. *American journal of physical medicine & rehabilitation*, 83(9), 713-719.

Atalay, N. S., Ercidogan, O., Akkaya, N., & Sahin, F. (2014). Prednisolone in complex regional pain syndrome. *Pain Physician*, *17*(2), 179-185.

Baldry, P. (2005). The Integration of Acupuncture within Medicine in the UK–the British Medical Acupuncture Society—s 25Th Anniversary. *Acupuncture in Medicine*, *23*(1), 2-12.

Basmajian, J. V., & Bazant, F. J. (1959). Factors Preventing Downward Dislocation Of The Adducted Shoulder Joint An Electromyographic And Morphological Study. *The Journal of Bone & Joint Surgery*, 41(7), 1182-1186.

Baykal, T., & Şenel, K. (2013). The comparison of the effects of the combination of physical therapy modalities and local corticosteroid therapy and alone physical therapy in the patients with hemiplegic should pain. *Turkish Journal of Geriatrics/Türk Geriatri Dergisi*, *16*(4).

Bell, K. R., & Williams, F. (2003). Use of botulinum toxin type A and type B for spasticity in upper and lower limbs. *Physical medicine and rehabilitation clinics of North America*, *14*(4), 821-835.

Bender, L., & McKenna, K. (2001). Hemiplegic Shoulder Pain: Defining The Problem And Its Management. *Disabil Rehabil*, 23(16), 698-705.

Benecke, R., Jost, W. H., Kanovsky, P., Ruzicka, E., Comes, G., & Grafe, S. (2005). A new botulinum toxin type A free of complexing proteins for treatment of cervical dystonia. *Neurology*, *64*(11), 1949-1951.

Bianchi, C., Rossi, S., Turi, S., & Brambilla, A. (2006). Long-term functional outcome measures in corticosteroid-treated complex regional pain syndrome. *European Journal of Physical and Rehabilitation Medicine*, *42*(2), 103.

Blow, D. (2012). *Neuromuscular Taping: From Theory to Practice.* Italy: EDI-Ermes.

Blackburn, M., Van Vliet, P., & Mockett, S. P. (2002). Reliability of measurements obtained with the modified Ashworth scale in the lower extremities of people with stroke. Physical therapy, 82(1), 25-34.

Bobath, D. (2012). *Adult Hemiplegia: Evaluation and Treatment* (3 ed.): Heinemann Medical Books Oxford.

Bohannon, R. W., & Andrews, A. W. (1990). Shoulder Subluxation And Pain In Stroke Patients. *The American Journal of Occupational Therapy*, 44(6), 507-509.

Bohannon, R. W. (1988). Relationship Between Shoulder Pain And Selected Variables In Patients With Hemiplegia. *Clinical rehabilitation*, 2(2), 111-117.

Bohannon, R. W., Larkin, P. A., Smith, M. B., & Horton, M. G. (1986). Shoulder Pain In Hemiplegia: Statistical Relationship With Five Variables. *Arch Phys Med Rehabil*, 67(8), 514-516.

Boonsong, P., Jarernpornwattana, A., & Boonhong, J. (2009). Preliminary study of suprascapular nerve block (SSNB) in hemiplegic shoulder pain. *Medical journal of the Medical Association of Thailand*, *92*(12), 1669.

Brashear, A., Gordon, M. F., Elovic, E., Kassicieh, V. D., Marciniak, C., Do, M., ... & Turkel, C. (2002). Intramuscular injection of botulinum toxin for the treatment of wrist and finger spasticity after a stroke. *New England Journal of Medicine*, *347*(6), 395-400.

Braus, D. F., Krauss, J. K., & Strobel, J. (1994). The shoulder–hand syndrome after stroke: a prospective clinical trial. *Annals of Neurology: Official Journal of the American Neurological Association and the Child Neurology Society*, *36*(5), 728-733.

Breckenridge, J. D., & McAuley, J. H. (2011). Shoulder pain and disability index (SPADI). *Journal of physiotherapy*, *57*(3), 197.

Brown, A. R., Weiss, R., Greenberg, C., Flatow, E. L., & Bigliani, L. U. (1993). Interscalene block for shoulder arthroscopy: comparison with general anesthesia. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*, *9*(3), 295-300.

Bullock, M. P., Foster, N. E., & Wright, C. C. (2005). Shoulder impingement: the effect of sitting posture on shoulder pain and range of motion. *Manual therapy*, *10*(1), 28-37.

Burgar, C. G., Lum, P. S., Shor, P. C., & Van der Loos, H. M. (2000). Development of robots for rehabilitation therapy: The Palo Alto VA/Stanford experience. *Journal of rehabilitation research and development*, *37*(6), 663-674.

Cacchio, A., De Blasis, E., De Blasis, V., Santilli, V., & Spacca, G. (2009). Mirror therapy in complex regional pain syndrome type 1 of the upper limb in stroke patients. *Neurorehabilitation and neural repair*, *23*(8), 792-799.

Cacchio, A., De Blasis, E., Necozione, S., Orio, F. D., & Santilli, V. (2009). Mirror therapy for chronic complex regional pain syndrome type 1 and stroke. *New England Journal of Medicine*, *361*(6), 634-636.

Cameron, D., & Bohannon, R. W. (2000). Criterion validity of lower extremity Motricity Index scores. *Clinical rehabilitation*, *14*(2), 208-211.

Cepeda, M. S., Lau, J., & Carr, D. B. (2002). Defining the therapeutic role of local anesthetic sympathetic blockade in complex regional pain syndrome: a narrative and systematic review. *The Clinical journal of pain*, *18*(4), 216-233.

Chaco, J., & Wolf, E. (1971). Subluxation Of The Glenohumeral Joint In Hemiplegia. *American journal of physical medicine & rehabilitation*, 50(3), 139-143.

Chatterjee, S., Hayner, K. A., Arumugam, N., Goyal, M., Midha, D., Arora, A., ... & Kumar, S. P. (2016). The California tri-pull taping method in the treatment of shoulder subluxation after stroke: a randomized clinical trial. *North American journal of medical sciences*, *8*(4), 175.

Chen, L. L., Su, Y. C., Su, C. H., Lin, H. C., & Kuo, H. W. (2008). Acupressure and meridian massage: combined effects on increasing body weight in premature infants. *Journal of Clinical Nursing*, *17*(9), 1174-1181.

Choi, G. S., & Chang, M. C. (2018). Effects of high-frequency repetitive transcranial magnetic stimulation on reducing hemiplegic shoulder pain in patients with chronic stoke: a randomized controlled trial. *International Journal of Neuroscience*, *128*(2), 110-116.

Chu, D. S., Petrillo, C., Davis, S. W., & Eichberg, R. (1981). Should-Hand Syndrome: Importance Of Early Diagnosis And Treatment. *Journal of the American Geriatrics Society*, 29(2), 58.

Chuang, I. C., Lin, K. C., Wu, C. Y., Hsieh, Y. W., Liu, C. T., & Chen, C. L. (2017). Using Rasch Analysis to Validate the Motor Activity Log and the Lower Functioning Motor Activity Log in Patients With Stroke. *Physical therapy*, 97(10), 1030-1040.

Codman, E. A. (1934). The Shoulder, 1934. Thomas Todd, Boston.

Cole, T. M., & Tobis, J. S. (1990). Measurement Of Musculoskeletal Function. Krusen's Handbook of Physical Medicine and Rehabilitation, ed, 3, 30-31.

Davis, K. D., Kwan, C. L., Crawley, A. P., & Mikulis, D. J. (1998). Functional MRI study of thalamic and cortical activations evoked by cutaneous heat, cold, and tactile stimuli. *Journal of Neurophysiology*, *80*(3), 1533-1546.

Davis, S. W., Petrillo, C. R., Eichberg, R. D., & Chu, D. S. (1977). Shoulder-Hand Syndrome In A Hemiplegic Population: A 5-Year Retrospective Study. Archives of physical medicine and rehabilitation, 58(8), 353.

Dean, C. M., Mackey, F. H., & Katrak, P. (2000). Examination of shoulder positioning after stroke: a randomised controlled pilot trial. *Australian Journal of Physiotherapy*, *46*(1), 35-40.

De Boer, K. S., Arwert, H. J., De Groot, J. H., Meskers, C. G. M., Mishre, A. R., & Arendzen, J. H. (2008). Shoulder pain and external rotation in spastic hemiplegia do not improve by injection of botulinum toxin A into the subscapular muscle. *Journal of Neurology, Neurosurgery & Psychiatry*, *79*(5), 581-583.

De Domenico, G. (1981). *Basic guidelines for interferential therapy*. Theramed Books.

De Domenico, G. (1987). *New dimensions in interferential therapy: a theoretical and clinical guide*. Curtin University of Technology.

de Jong, L. D., Nieuwboer, A., & Aufdemkampe, G. (2006). Contracture preventive positioning of the hemiplegic arm in subacute stroke patients: a pilot randomized controlled trial. *Clinical rehabilitation*, *20*(8), 656-667.

de Vries, N. J., Sloot, P. H., & Achterberg, W. P. (2017). Pain and pain assessment in stroke patients with aphasia: a systematic review. *Aphasiology*, *31*(6), 703-719.

Devier, D., Harnar, J., Lopez, L., Brashear, A., & Graham, G. (2017). Rehabilitation plus OnabotulinumtoxinA Improves Motor Function over OnabotulinumtoxinA Alone in Post-Stroke Upper Limb Spasticity: A Single-Blind, Randomized Trial. *Toxins*, *9*(7), 216.

Di, H. Y., Han, S. K., Du, X. L., Li, W. W., & Jia, J. (2017). Applying tuina to exterior-interiorly connected meridians for post-stroke upper limb spasticity. *Journal of Acupuncture and Tuina Science*, *15*(1), 27-30.

Dionisio, A., Duarte, I. C., Patricio, M., & Castelo-Branco, M. (2018). The use of repetitive transcranial magnetic stimulation for stroke rehabilitation: a systematic review. *Journal of Stroke and Cerebrovascular Diseases*, *27*(1), 1-31.

dos Santos, G. L., Souza, M. B., Desloovere, K., & Russo, T. L. (2017). Elastic tape improved shoulder joint position sense in chronic hemiparetic subjects: a randomized sham-controlled crossover study. *PloS one*, *12*(1), e0170368.

Dromerick, A. W., Edwards, D. F., & Kumar, A. (2008). Hemiplegic shoulder pain syndrome: frequency and characteristics during inpatient stroke rehabilitation. *Archives of physical medicine and rehabilitation*, *89*(8), 1589-1593.

English, C. K., Thoirs, K. A., Fisher, L., McLennan, H., & Bernhardt, J. (2012). Ultrasound is a reliable measure of muscle thickness in acute stroke patients, for some, but not all anatomical sites: a study of the intra-rater reliability of muscle thickness measures in acute stroke patients. *Ultrasound in medicine & biology*, *38*(3), 368-376.

Eraifej, J., Clark, W., France, B., Desando, S., & Moore, D. (2017). Effectiveness of upper limb functional electrical stimulation after stroke for the improvement of activities of daily living and motor function: a systematic review and meta-analysis. *Systematic reviews*, *6*(1), 40.

Faghri, P. D., Rodgers, M. M., Glaser, R. M., Bors, J. G., Ho, C., & Akuthota, P. (1994). The effects of functional electrical stimulation on shoulder subluxation, arm function recovery, and shoulder pain in hemiplegic stroke patients. *Archives of physical medicine and rehabilitation*, *75*(1), 73-79.

Fil, A., Armutlu, K., Atay, A. O., Kerimoglu, U., & Elibol, B. (2011). The effect of electrical stimulation in combination with Bobath techniques in the prevention of shoulder subluxation in acute stroke patients. *Clinical rehabilitation*, *25*(1), 51-59.

Fitzgerald-Finch, O. P., & Gibson, I. I. (1975). Subluxation Of The Shoulder In Hemiplegia. *Age and ageing*, 4(1), 16-18.

Francisco, G. E., Boake, C., & Vaughn, A. (2002). Botulinum toxin in upper limb spasticity after acquired brain injury: a randomized trial comparing dilution techniques. *American journal of physical medicine & rehabilitation*, *81*(5), 355-363.

Fulk, G., Martin, R., & Page, S. J. (2017). Clinically important difference of the arm motor ability test in Stroke survivors. *Neurorehabilitation and neural repair*, *31*(3), 272-279.

Gaffney, K., Ledingham, J., & Perry, J. D. (1995). Intra-articular triamcinolone hexacetonide in knee osteoarthritis: factors influencing the clinical response. *Annals of the rheumatic diseases*, *54*(5), 379-381.

Gelnar, P. A., Krauss, B. R., Sheehe, P. R., Szeverenyi, N. M., & Apkarian, A. V. (1999). A comparative fMRI study of cortical representations for thermal painful, vibrotactile, and motor performance tasks. *Neuroimage*, *10*(4), 460-482.

Geurts, A. C., Visschers, B. A., Van Limbeek, J., & Ribbers, G. M. (2000). Systematic review of aetiology and treatment of post-stroke hand oedema and shoulder-hand syndrome. *Scand J Rehabil Med*, *32*(1), 4-10.

Gezer, H., Karaahmet, O. Z., Gurcay, E., Dulgeroglu, D., & Cakci, A. (2019). The effect of aerobic exercise on stroke rehabilitation. *Irish Journal of Medical Science (1971-)*, *188*(2), 469-473.

González, N., Bilbao, A., Forjaz, M. J., Ayala, A., Orive, M., Garcia-Gutierrez, S., ... & Quintana, J. M. (2018). Psychometric characteristics of the Spanish version of the Barthel Index. Aging clinical and experimental research, 30(5), 489-497.

González-Escalada, J. R., Camba, A., Muriel, C., Rodríguez, M., Contreras, D. de Barutell, C. (2012). Validación del índice de Lattinen para la evaluación del paciente con dolor crónico. *Rev Soc Esp Dolor, 19,* 181–8.

Gottlieb, N. L., & Riskin, W. G. (1980). Complications of local corticosteroid injections. *Jama*, *243*(15), 1547-1548.

Granger, C. V., Cotter, A. C., Hamilton, B. B., & Fiedler, R. C. (1993). Functional assessment scales: a study of persons after stroke. Archives of physical medicine and rehabilitation, 74(2), 133-138.

Granger, C. V., Deutsch, A., & Linn, R. T. (1998). Rasch analysis of the Functional Independence Measure (FIM™) mastery test. Archives of physical medicine and rehabilitation, 79(1), 52-57.

Griffin, A., & Bernhardt, J. (2006). Strapping the hemiplegic shoulder prevents development of pain during rehabilitation: a randomized controlled trial. *Clinical rehabilitation*, *20*(4), 287-295.

Grossens-Sills, J., & Schenkman, M. (1985). Analysis Of Shoulder Pain, Range Of Motion, And Subluxation In Patients With Hemiplegia. *Physical Therapy*, 65-73.

Gustafsson, L., & McKenna, K. (2006). A programme of static positional stretches does not reduce hemiplegic shoulder pain or maintain shoulder range of motion-a randomized controlled trial. *Clinical rehabilitation*, *20*(4), 277-286.

Han, J. S., & Terenius, L. (1982). Neurochemical basis of acupuncture analgesia. *Annual review of pharmacology and toxicology*, *22*(1), 193-220.

Hanger, H. C., Whitewood, P., Brown, G., Ball, M. C., Harper, J., Cox, R., & Sainsbury, R. (2000). A randomized controlled trial of strapping to prevent post-stroke shoulder pain. *Clinical rehabilitation*, *14*(4), 370-380.

Harden, R. N., Oaklander, A. L., Burton, A. W., Perez, R. S., Richardson, K., Swan, M., ... & Bruehl, S. (2013). Complex regional pain syndrome: practical diagnostic and treatment guidelines. *Pain medicine*, *14*(2), 180-229.

Hartwig, M., Gelbrich, G., & Griewing, B. (2012). Functional orthosis in shoulder joint subluxation after ischaemic brain stroke to avoid post-hemiplegic shoulder–hand syndrome: A randomized clinical trial. *Clinical rehabilitation*, *26*(9), 807-816.

Hayner, K. A. (2012). Effectiveness of the California Tri-Pull Taping method for shoulder subluxation poststroke: A single-subject ABA design. *American Journal of Occupational Therapy*, *66*(6), 727-736.

Hecht, J. (1995). The Role Of Spasticity In Hemiplegic Shoulder Pain And What To Do About It. . Paper presented at the 57th Annual Assembly Of The American Academy Of Physical Medicine And Rehabilitation, Orlando,Florida

Heller, A., Wade, D. T., Wood, V. A., Sunderland, A., Hewer, R. L., & Ward, E. (1987). Arm function after stroke: measurement and recovery over the first three months. Journal of Neurology, Neurosurgery & Psychiatry, 50(6), 714-719.

Higa, K., Hirata, K., Hirota, K., Nitahara, K., & Shono, S. (2006). Retropharyngeal hematoma after stellate ganglion blockAnalysis of 27 patients reported in the literature. *Anesthesiology: The Journal of the American Society of Anesthesiologists*, *105*(6), 1238-1245.

Hochsprung, A., Domínguez-Matito, A., López-Hervás, A., Herrera-Monge, P., Moron-Martin, S., Ariza-Martínez, C., ... & Heredia-Rizo, A. M. (2017). Short-and medium-term effect of kinesio taping or electrical stimulation in hemiplegic shoulder pain prevention: A randomized controlled pilot trial. *NeuroRehabilitation*, *41*(4), 801-810.

Holland, B., & Pokorny, M. E. (2001). Slow stroke back massage: its effect on patients in a rehabilitation setting. *Rehabilitation Nursing*, *26*(5), 182-186.

Hollinshead, W. H., & Jenkins, D. B. (1981). Functional Anatomy Of The Limbs And Neck. Philadelphia: Saunders.

Huang, Y. C., Chang, K. H., Liou, T. H., Cheng, C. W., Lin, L. F., & Huang, S. W. (2017). Effects of Kinesio taping for stroke patients with hemiplegic shoulder pain: a double-blind, randomized, placebo-controlled study. *Journal of rehabilitation medicine*, *49*(3), 208-215.

Huang, Y. C., Leong, C. P., Wang, L., Chen, M. J., Chuang, C. Y., Liaw, M. Y., & Wang, L. Y. (2016). The effects of hyaluronic acid on hemiplegic shoulder injury and pain in patients with subacute stroke: a randomized controlled pilot study. *Medicine*, *95*(49).

Huang, Y. C., Leong, C. P., Wang, L., Wang, L. Y., Yang, Y. C., Chuang, C. Y., & Hsin, Y. J. (2016). Effect of kinesiology taping on hemiplegic shoulder pain and functional outcomes in subacute stroke patients: a randomized controlled study. *European journal of physical and rehabilitation medicine*, *52*(6), 774-781.

Hulmes, D. J. S., Marsden, M. E., Strachan, R. K., Harvey, R. E., McInnes, N., & Gardner, D. L. (2004). Intra-articular hyaluronate in experimental rabbit osteoarthritis can prevent changes in cartilage proteoglycan content. *Osteoarthritis and cartilage*, *12*(3), 232-238.

Ikai, T., Tei, K., Yoshida, K., Miyano, S., & Yonemoto, K. (1998). Evaluation And Treatment Of Shoulder Subluxation In Hemiplegia: Relationship Between Subluxation And Pain. *American journal of physical medicine & rehabilitation*, 77(5), 421-426.

Inaba, M. K., & Piorkowski, M. (1972). Ultrasound in treatment of painful shoulders in patients with hemiplegia. *Physical therapy*, *52*(7), 737-742.

Iwata, M., Kondo, I., Sato, Y., Satoh, K., Soma, M., & Bar-Or, O. (2002). Prediction Of Reflex Sympathetic

Dystrophy In Hemiplegia By Evaluation Of Hand Edema. Archives of physical medicine and rehabilitation, 83(10), 1428-1431.

Jan, F., Naeem, A., Malik, A. N., Amjad, I., & Malik, T. (2017). Comparison of low level laser therapy and interferential current on post stroke shoulder pain. *J Pak Med Assoc*, *67*(5), 788-789.

Jang, M. H., Lee, C. H., Shin, Y. I., Kim, S. Y., & Huh, S. C. (2016). Effect of intra-articular hyaluronic acid injection on hemiplegic shoulder pain after stroke. *Annals of rehabilitation medicine*, *40*(5), 835.

Jang, S. H., Kwon, Y. H., Lee, M. Y., Lee, D. Y., & Hong, J. H. (2012). Difference of neural connectivity for motor function in chronic hemiparetic stroke patients with intracerebral hemorrhage. *Neuroscience letters, 531*(2), 80-85.

Jaraczewska, E., & Long, C. (2006). Kinesio® taping in stroke: improving functional use of the upper extremity in hemiplegia. *Topics in Stroke rehabilitation*, *13*(3), 31-42.

Jeon, S., Kim, Y., Jung, K., & Chung, Y. (2017). The effects of electromyography-triggered electrical stimulation on shoulder subluxation, muscle activation, pain, and function in persons with stroke: A pilot study. *NeuroRehabilitation*, *40*(1), 69-75.

Jerosch-Herold, C., Chester, R., Shepstone, L., Vincent, J. I., & MacDermid, J. C. (2018). An evaluation of the structural validity of the shoulder pain and disability index (SPADI) using the Rasch model. *Quality of Life Research*, *27*(2), 389-400.

Johnson, M. (2007). Transcutaneous electrical nerve stimulation: mechanisms, clinical application and evidence. *Reviews in pain*, *1*(1), 7-11.

Johnstone, M. (1982). *The Stroke Patient: Principles of Rehabilitation:* Churchill Livingstone.

Jost, W. H., Kohl, A., Brinkmann, S., & Comes, G. (2005). Efficacy and tolerability of a botulinum toxin type A free of complexing proteins (NT 201) compared with commercially available botulinum toxin type A (BOTOX) in healthy volunteers. *Journal of neural transmission*, *112*(7), 905-913.

Joynt, R. L. (1992). The Source Of Shoulder Pain In Hemiplegia. *Arch Phys Med Rehabil*, 73(5), 409-413

Kalichman, L., & Ratmansky, M. (2011). Underlying Pathology And Associated Factors Of Hemiplegic Shoulder Pain. American journal of physical medicine & rehabilitation, 90(9), 768-780.

Kalita, J., Misra, U., Kumar, A., & Bhoi, S. K. (2016). Long-term prednisolone in post-stroke complex regional pain syndrome. *Pain physician*, *19*(8), 565-574.

Kalita, J., Vajpayee, A., & Misra, U. K. (2006). Comparison of prednisolone with piroxicam in complex regional pain syndrome following stroke: a randomized controlled trial. *Qjm*, *99*(2), 89-95.

Kapral, S., Krafft, P., Gosch, M., Weinstabl, C., & Fleischmann, D. (1995). Ultrasound imaging for stellate ganglion block: direct visualization of puncture site and local anesthetic spread: a pilot study. *Reg Anesth Pain Med*, *20*(4), 323-328.

Karaahmet, O. Z., Eksioglu, E., Gurcay, E., Karsli, P. B., Tamkan, U., Bal, A., & Cakci, A. (2014). Hemiplegic Shoulder Pain: Associated Factors And Rehabilitation Outcomes Of Hemiplegic Patients With And Without Shoulder Pain. *Topics in Stroke Rehabilitation*, 21(3), 237-245.

Kim, E. K., & Kwak, K. I. (2016). Effect of extracorporeal shock wave therapy on the shoulder joint functional status of patients with calcific tendinitis. *Journal of physical therapy science*, *28*(9), 2522-2524.
Kim, S. H., Ha, K. W., Kim, Y. H., Seol, P. H., Kwak, H. J., Park, S. W., & Ryu, B. J. (2016). Effect of radial extracorporeal shock wave therapy on hemiplegic shoulder pain syndrome. *Annals of rehabilitation medicine*, *40*(3), 509.

Kitoh, Y., Katsuramaki, T., Tanaka, H., Tanaka, M., Kitabayashi, N., Kataoka, M., ... & Namba, K. (1992). Effect of SL-1010 (sodium hyaluronate with high molecular weight) on experimental osteoarthritis induced by intra-articularly applied papain in rabbits. *Nihon yakurigaku zasshi. Folia pharmacologica Japonica*, *100*(1), 67-76.

Klich, S., Kisilewicz, A., Pożarowszczyk, B., Zatoń, M., Kawczyński, A., & Michener, L. A. (2019). Shoulder tendon characteristics in disabled swimmers in high functional classes–Preliminary report. *Physical Therapy in Sport*, *35*, 23-28.

Knutson, J. S., Fu, M. J., Sheffler, L. R., & Chae, J. (2015). Neuromuscular electrical stimulation for motor restoration in hemiplegia. *Physical medicine and rehabilitation clinics of North America*, *26*(4), 729.

Kong, K. H., Neo, J. J., & Chua, K. S. (2007). A randomized controlled study of botulinum toxin A in the treatment of hemiplegic shoulder pain associated with spasticity. *Clinical rehabilitation*, *21*(1), 28-35.

Koyuncu, E., Nakipoğlu-Yüzer, G. F., Doğan, A., & Özgirgin, N. (2010). The effectiveness of functional electrical stimulation for the treatment of shoulder subluxation and shoulder pain in hemiplegic patients: A randomized controlled trial. *Disability and Rehabilitation*, *32*(7), 560-566.

Kozin, F., Ryan, L. M., Carerra, G. F., Soin, J. S., & Wortmann, R. L. (1981). The Reflex Sympathetic Dystrophy Syndrome (Rsds): Iii. Scintigraphic Studies, Further Evidence For The Therapeutic Efficacy Of Systemic Corticosteroids, And Proposed Diagnostic Criteria. The American journal of medicine, 70(1), 23-30.

Krebs, E. E., Carey, T. S., & Weinberger, M. (2007). Accuracy of the pain numeric rating scale as a screening test in primary care. *Journal of general internal medicine*, *22*(10), 1453-1458.

Külcü, D. G., Taraktaş, A., Badur, N., Çizmeci, P., Özkan, F. Ü., & Aktaş, İ. (2017). Blinded and stimulator guided comparison of suprascapular nerve block in hemiplegic shoulder pain: a pilot study. *Turkish Journal of Physical Medicine & Rehabilitation/Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi*, *63*(1).

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*(4), 205-208.

Lakse, E., Gunduz, B., Erhan, B., & Celik, E. C. (2009). The effect of local injections in hemiplegic shoulder pain: a prospective, randomized, controlled study. *American journal of physical medicine & rehabilitation*, *88*(10), 805-811.

Lee, J. H., Baker, L. L., Johnson, R. E., & Tilson, J. K. (2017). Effectiveness of neuromuscular electrical stimulation for management of shoulder subluxation post-stroke: a systematic review with meta-analysis. *Clinical rehabilitation*, *31*(11), 1431-1444.

Leggin, B. G., Michener, L. A., Shaffer, M. A., Brenneman, S. K., Iannotti, J. P., & Williams Jr, G. R. (2006). The Penn shoulder score: reliability and validity. *Journal of orthopaedic & sports physical therapy*, *36*(3), 138-151.

Li, N., Tian, F., Wang, C., Yu, P., Zhou, X., Wen, Q., ... & Huang, L. (2012). Therapeutic effect of acupuncture and massage for shoulder-hand syndrome in hemiplegia patients: a clinical two-center randomized controlled trial. *Journal of Traditional Chinese Medicine*, *32*(3), 343-349.

Lin, J. D., Lin, L. P., Su, S. F., Hsu, S. W., Chou, Y. C., Lin, F. G., ... & Chu, C. M. (2014). The interference of low back pain on everyday functions of life in care workers for persons with intellectual, autistic, and associated multiple disabilities: The Brief Pain Inventory short form (BPI-SF) survey. *Research in Autism Spectrum Disorders*, *8*(6), 692-700.

Lin, C. H., Chen, K. H., Chang, C. H., Chen, C. M., Huang, Y. C., Hsu, H. C., & Hong, C. Z. (2014). Muscle Pain Intensity And Pressure Pain Threshold Changes In Different Periods Of Stroke Patients. *American journal of physical medicine & rehabilitation*, 93(4), 299-309.

Linacre, J. M., Heinemann, A. W., Wright, B. D., Granger, C. V., & Hamilton, B. B. (1994). The structure and stability of the Functional Independence Measure. Archives of physical medicine and rehabilitation, 75(2), 127-132.

Lim, J. Y., Koh, J. H., & Paik, N. J. (2008). Intramuscular botulinum toxin-A reduces hemiplegic shoulder pain: a randomized, double-blind, comparative study versus intraarticular triamcinolone acetonide. *Stroke*, *39*(1), 126-131.

Lo, Y. L., Cui, S. L., & Fook-Chong, S. (2005). The effect of acupuncture on motor cortex excitability and plasticity. *Neuroscience letters*, *384*(1-2), 145-149.

Low, J., & Reed, A. (2000). Electrical stimulation of nerve and muscle. *Electrotherapy explained: principles and practice. 3ª ed. Oxford: Butterworth-Heinemann*, 53-139.

Lynch, D., Ferraro, M., Krol, J., Trudell, C. M., Christos, P., & Volpe, B. T. (2005). Continuous passive motion improves shoulder joint integrity following stroke. *Clinical rehabilitation*, *19*(6), 594-599.

Mahabier, K. C., Den Hartog, D., Theyskens, N., Verhofstad, M. H., Van Lieshout, E. M., Bos, P. K., ... & Eversdijk, M. G. (2017). Reliability, validity, responsiveness, and minimal important change of the disabilities of the arm, shoulder and hand and constant-murley scores in patients with a humeral shaft fracture. *Journal of shoulder and elbow surgery*, *26*(1), e1-e12.
Mahli, A., Coskun, D., & Akcali, D. T. (2002). Aetiology of convulsions due to stellate ganglion block: a review and report of two cases. *European journal of anaesthesiology*, *19*(5), 376-380.

Marciniak, C. M., Harvey, R. L., Gagnon, C. M., Duraski, S. A., Denby, F. A., McCarty, S., ... & Fierstein, K. M. (2012). Does botulinum toxin type A decrease pain and lessen disability in hemiplegic survivors of stroke with shoulder pain and spasticity?: a randomized, double-blind, placebo-controlled trial. *American journal of physical medicine & rehabilitation*, *91*(12), 1007-1019.

Marco, E., Duarte, E., Vila, J., Tejero, M., Guillen, A., Boza, R., ... & Espadaler, J. M. (2007). Is botulinum toxin type A effective in the treatment of spastic shoulder pain in patients after stroke? A double-blind randomized clinical trial. *Journal of rehabilitation medicine*, *39*(6), 440-447.

Martin, R., & Page, S. J. (2017). Clinically important difference of the arm motor ability test in Stroke survivors. *Neurorehabilitation and neural repair*, *31*(3), 272-279.

McKenna, L. B. K. (2001). Hemiplegic shoulder pain: defining the problem and its management. *Disability and rehabilitation*, *23*(16), 698-705.

Mehrholz, J., Wagner, K., Meissner, D., Grundmann, K., Zange, C., Koch, R., & Pohl, M. (2005). Reliability of the Modified Tardieu Scale and the Modified Ashworth Scale in adult patients with severe brain injury: a comparison study. Clinical rehabilitation, 19(7), 751-759.

Mendigutia-Gómez, A., Martín-Hernández, C., Salom-Moreno, J., & Fernández-de-las-Peñas, C. (2016). Effect of dry needling on spasticity, shoulder range of motion, and pressure pain sensitivity in patients with stroke: a crossover study. *Journal of manipulative and physiological therapeutics*, *39*(5), 348-358.

Mendoza, T., Mayne, T., Rublee, D., & Cleeland, C. (2006). Reliability and validity of a modified Brief Pain Inventory short form in patients with osteoarthritis. *European Journal of Pain*, *10*(4), 353-353.

Mohamed, R. E., Amin, M. A., & Aboelsafa, A. A. (2014). Ultrasonographic And Clinical Study Of PostStroke Painful Hemiplegic Shoulder. *The Egyptian Journal of Radiology and Nuclear Medicine*, 45(4), 1163-1170.

Mok, E., & Woo, C. P. (2004). The effects of slow-stroke back massage on anxiety and shoulder pain in elderly stroke patients. *Complementary Therapies in Nursing and Midwifery*, *10*(4), 209-216.

Moniruzzaman, M., Salek, K. M., Shakoor, M. A., Mia, B. A., & Moyeenuzzaman, M. (2010). Effects of Therapeutic Modalities on Patients with Post Stroke Shoulder. *Mymensingh Med J*, *19*(1), 48-53.

Monte-Silva, K., Piscitelli, D., Norouzi-Gheidari, N., Batalla, M. A. P., Archambault, P., & Levin, M. F. (2019). Electromyogram-related neuromuscular electrical stimulation for restoring wrist and hand movement in poststroke hemiplegia: a systematic review and meta-analysis. *Neurorehabilitation and neural repair*, *33*(2), 96-111.

Morin, L., & Bravo, G. (1997). Strapping the hemiplegic shoulder: a radiographic evaluation of its efficacy to reduce subluxation. *Physiotherapy Canada*, *49*(2), 103.

Moseley, G. L. (2006). Graded motor imagery for pathologic pain: a randomized controlled trial. *Neurology*, *67*(12), 2129-2134.

Moseley, G. L. (2004). Graded motor imagery is effective for long-standing complex regional pain syndrome: a randomised controlled trial. *Pain*, *108*(1-2), 192-198.

Moskowitz, H., Goodman, C. R., Smith, E., Balthazar, E., & Mellins, H. Z. (1969). Hemiplegic Shoulder. New York state journal of medicine, 69(4), 548.

Mueller, M. J., Sorensen, C. J., McGill, J. B., Clark, B. R., Lang, C. E., Chen, L., ... & Hastings, M. K. (2018). Effect of a Shoulder Movement Intervention on Joint Mobility, Pain, and Disability in People With Diabetes: A Randomized Controlled Trial. *Physical therapy*, *98*(9), 745-753.

Naghdi, S., Ansari, N. N., Mansouri, K., & Hasson, S. (2010). A neurophysiological and clinical study of Brunnstrom recovery stages in the upper limb following stroke. *Brain injury*, 24(11), 1372-1378.

Najenson, T., Yacubovich, E., & Pikielni, S. S. (1971). Rotator Cuff Injury In Shoulder Joints Of Hemiplegic Patients. *Scandinavian journal of rehabilitation medicine*, 3(3), 131.

Nakazawa, F., Matsuno, H., Yudoh, K., Watanabe, Y., Katayama, R., & Kimura, T. (2002). Corticosteroid treatment induces chondrocyte apoptosis in an experimental arthritis model and in chondrocyte cultures. *Clinical and experimental rheumatology*, *20*(6), 773-782.

Narouze, S., Vydyanathan, A., & Patel, N. (2007). Ultrasound-guided stellate ganglion block successfully prevented esophageal puncture. *Pain Physician*, *10*(6), 747.

Nascimento, L. R., Michaelsen, S. M., Ada, L., Polese, J. C., & Teixeira-Salmela, L. F. (2014). Cyclical electrical stimulation increases strength and improves activity after stroke: a systematic review. *Journal of physiotherapy*, *60*(1), 22-30.

Nayak, R., & Banik, R. K. (2018). Current Innovations in Peripheral Nerve Stimulation. *Pain research and treatment*, *2018*.

Nepomuceno, C. S., & Miller, J. M. I. (1974). Shoulder Arthrography In Hemiplegic Patients. *Archives of physical medicine and rehabilitation*, 55(2), 49.

Newton, R. A. (1984). *Electrotherapeutic Treatment: Selecting Appropriate Waveform Characteristics*. JA Preston Corporation.

Ni, H. H., Wu, Y. C., Shi, X. D., Li, Y., Zhang, Y. Y., Zeng, H. L., ... & Huang, C. S. (2017). Community promotion of superficial needling plus club swing for post-stroke motion impairment of the shoulder joint. *Journal of Acupuncture and Tuina Science*, *15*(2), 109-114.

Nilsson, L., Carlsson, J., Danielsson, A., Fugl-Meyer, A., Hellström, K., Kristensen, L., ... & Grimby, G. (2001). Walking training of patients with hemiparesis at an early stage after stroke: a comparison of walking training on a treadmill with body weight support and walking training on the ground. Clinical Rehabilitation, 15(5), 515-527.

Nomikos, P. A., Spence, N., & Alshehri, M. A. (2018). Test-retest reliability of physiotherapists using the action research arm test in chronic stroke. *Journal of Physical Therapy Science*, *30*(10), 1271-1277.

O'Dell, M. W., Kim, G., Finnen, L. R., & Polistena, C. (2011). Clinical implications of using the arm motor ability test in stroke rehabilitation. *Archives of physical medicine and rehabilitation*, *92*(5), 830-836.

O'Dell, M. W., Kim, G., Rivera, L., Fieo, R., Christos, P., Polistena, C., ... & Gorga, D. (2013). A psychometric evaluation of the Arm Motor Ability Test. *Journal of rehabilitation medicine*, *45*(6), 519-527.

Ogden, J. A., Tóth-Kischkat, A., & Schultheiss, R. (2001). Principles of shock wave therapy. *Clinical Orthopaedics and Related Research (1976-2007)*, *387*, 8-17.

Okuyama, K., Ogura, M., Kawakami, M., Tsujimoto, K., Okada, K., Miwa, K., ... & Liu, M. (2018). Effect of the combination of motor imagery and electrical stimulation on upper extremity motor function in patients with chronic stroke: preliminary results. Therapeutic advances in neurological disorders, 11, 1756286418804785

Paci, M., Nannetti, L., Taiti, P., Baccini, M., & Rinaldi, L. (2007). Shoulder Subluxation After Stroke: Relationships With Pain And Motor Recovery. *Physiother Res Int*, 12(2), 95-104.

Paci, M., Nannetti, L., & Rinaldi, L. A. (2005). Glenohumeral Subluxation In Hemiplegia: An Overview. *Journal of rehabilitation research and development*, 42(4), 557.

Palmer, S. T., Martin, D. J., Steedman, W. M., & Ravey, J. (1999). Alteration of interferential current and transcutaneous electrical nerve stimulation frequency: effects on nerve excitation. *Archives of physical medicine and rehabilitation*, *80*(9), 1065-1071.

Pan, R., Zhou, M., Cai, H., Guo, Y., Zhan, L., Li, M., ... & Chen, H. (2018). A randomized controlled trial of a modified wheelchair arm-support to reduce shoulder pain in stroke patients. *Clinical rehabilitation*, *32*(1), 37-47.

Pandian, J. D., Kaur, P., Arora, R., Vishwambaran, D. K., Toor, G., Mathangi, S., ... & Arima, H. (2013). Shoulder taping reduces injury and pain in stroke patients: randomized controlled trial. *Neurology*, *80*(6), 528-532.

Pang, M. Y., Charlesworth, S. A., Lau, R. W., & Chung, R. C. (2013). Using aerobic exercise to improve health outcomes and quality of life in stroke: evidence-based exercise prescription recommendations. *Cerebrovascular diseases*, *35*(1), 7-22.

Parker, V. M., Wade, D. T., & Hewer, R. L. (1986). Loss of arm function after stroke: measurement, frequency, and recovery. International rehabilitation medicine, 8(2), 69-73.

Park, Chang-Sik (2018). "The test-retest reliability and minimal detectable change of the shortform Barthel Index (5 items) and its associations with chronic stroke-specific impairments." Journal of physical therapy science 30.6, 835-839.

Park, J., Lee, M. S., & Harrison, A. R. (2011). Profile of Xeomin®(incobotulinumtoxinA) for the treatment of blepharospasm. *Clinical Ophthalmology (Auckland, NZ)*, *5*, 725.

Partridge, C. J., Edwards, S. M., Mee, R., & Van Langenberghe, H. V. K. (1990). Hemiplegic shoulder pain: a study of two methods of physiotherapy treatment. *Clinical rehabilitation*, *4*(1), 43-49.

Pelletier, J. P., & Martel-Pelletier, J. (1989). Protective effects of corticosteroids on cartilage lesions and osteophyte formation in the Pond-Nuki dog model of osteoarthritis. *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology*, *32*(2), 181-193.

Peterchev, A. V., Wagner, T. A., Miranda, P. C., Nitsche, M. A., Paulus, W., Lisanby, S. H., ... & Bikson, M. (2012). Fundamentals of transcranial electric and magnetic stimulation dose: definition, selection, and reporting practices. *Brain stimulation*, *5*(4), 435-453.

Pillastrini, P., Rocchi, G., Deserri, D., Foschi, P., Mardegan, M., Naldi, M. T., ... & Bertozzi, L. (2016). Effectiveness of neuromuscular taping on painful hemiplegic shoulder: a randomised clinical trial. *Disability and rehabilitation*, *38*(16), 1603-1609.

Placzek, J. D., & Boyce, D. A. (2006). *Orthopaedic physical therapy secrets* (2nd ed.). St. Louis, Mo: Mosby Elsevier.

Poduri, K. R. (1993). Shoulder Pain In Stroke Patients And Its Effects On Rehabilitation. *Journal of Stroke and Cerebrovascular Diseases*, 3(4), 261-266.

Poquet, N., & Lin, C. (2016). The brief pain inventory (BPI). *Journal of physiotherapy*, *62*(1), 52.

Poulin, d. C., Barsauskas, A., Berenbaum, B., Dehaut, F., Dussault, R., Fontaine, F. S., Labrecque, R., Leclerc, C., & Giroux, F. (1990). Painful Shoulder In The Hemiplegic And Unilateral Neglect. *Archives of physical medicine and rehabilitation*, 71(9), 673.

Price, C. I. M., Curless, R. H., & Rodgers, H. (1999). Can stroke patients use visual analogue scales?. *Stroke*, *30*(7), 1357-1361.

Quinn, T. J., Dawson, J., Walters, M., & Lees, K. R. (2009). Reliability of the modified Rankin Scale: a systematic review. Stroke, 40(10), 3393-3395.

Quisel, A., Gill, J. M., & Witherell, P. (2005). Complex Regional Pain Syndrome: Which Treatments Show Promise? Journal of family practice, 54(7), 599.
Rabinstein, A. A., & Shulman, L. M. (2003). Acupuncture in clinical neurology. *The neurologist*, *9*(3), 137-148.

Rah, U. W., Yoon, S. H., Moon, D. J., Kwack, K. S., Hong, J. Y., Lim, Y. C., & Joen, B. (2012). Subacromial corticosteroid injection on poststroke hemiplegic shoulder pain: a randomized, triple-blind, placebo-controlled trial. *Archives of physical medicine and rehabilitation*, *93*(6), 949-956.

Rajaratnam, B. S., Venketasubramanian, N., Kumar, P. V., Goh, J. C., & Chan, Y. H. (2007). Predictability of simple clinical tests to identify shoulder pain after stroke. *Archives of physical medicine and rehabilitation*, *88*(8), 1016-1021.
Ratmansky, M., Defrin, R., & Soroker, N. (2012). A randomized controlled study of segmental neuromyotherapy for post-stroke hemiplegic shoulder pain. *Journal of rehabilitation medicine*, *44*(10), 830-836.

Ritchie, E. D., Tong, D., Chung, F., Norris, A. M., Miniaci, A., & Vairavanathan, S. D. (1997). Suprascapular nerve block for postoperative pain relief in arthroscopic shoulder surgery: a new modality?. *Anesthesia & Analgesia*, *84*(6), 1306-1312.

Roggenkämper, P., Jost, W. H., Bihari, K., Comes, G., Grafe, S., & NT 201 Blepharospasm Study Team. (2006). Efficacy and safety of a new botulinum toxin type A free of complexing proteins in the treatment of blepharospasm. *Journal of neural transmission*, *113*(3), 303-312.

Roy, J. S., MacDermid, J. C., & Woodhouse, L. J. (2010). A systematic review of the psychometric properties of the Constant-Murley score. *Journal of Shoulder and Elbow Surgery*, *19*(1), 157-164.
Roy, C. W., Sands, M. R., & Hill, L. D. (1994). Shoulder Pain In Acutely Admitted Hemiplegics. *Clinical rehabilitation*, 8(4), 334-340.
Safaz, I., Ylmaz, B., Yasar, E., & Alaca, R. (2009). Brunnstrom recovery stage and motricity index for the evaluation of upper extremity in stroke: analysis for correlation and responsiveness. International Journal of Rehabilitation Research, 32(3), 228-231.
Sanford, J., Moreland, J., Swanson, L. R., Stratford, P. W., & Gowland, C. (1993). Reliability of the Fugl-Meyer assessment for testing motor performance in patients following stroke. Physical therapy, 73(7), 447-454.
Savage, R., & Robertson, L. (1982). The Relationship Between Adult Hemiplegic Shoulder Pain And Depression. *Physiotherapy Canada*, 34, 86-176.
Scaglione, F. (2016). Conversion ratio between Botox®, Dysport®, and Xeomin® in clinical practice. *Toxins*, *8*(3), 65.

Schimmel, M., Leemann, B., Christou, P., Schnider, A., Müller, F., & Kiliaridis, S. (2010). Masseter muscle thickness in hospitalised stroke patients. *Journal of oral rehabilitation*, *37*(9), 726-730.
Sealey, P., & Critchley, D. (2017). Do isometric pull-down exercises increase the acromio-humeral distance?. *Physiotherapy*, *103*(2), 208-213.
Seo, Y. R., Jung, W. S., Park, S. U., Moon, S. K., Park, J. M., & Park, J. Y. (2013). The effect of ouhyul herbal acupuncture point injections on shoulder pain after stroke. *Evidence-Based Complementary and Alternative Medicine*, *2013*.

Shahani, B. T., Kelly, E. B., & Glasser, S. (1981). Hemiplegic Shoulder Subluxation. *Arch Phys Med Rehabil*, 62, 519.

Shai, G., Ring, H., Costeff, H., & Solzi, P. (1984). Glenohumeral Malalignment In The Hemiplegic Shoulder. An Early Radiologic Sign. *Scandinavian journal of rehabilitation medicine*, 16(3), 133.

Shin, B. C., & Lee, M. S. (2007). Effects of aromatherapy acupressure on hemiplegic shoulder pain and motor power in stroke patients: a pilot study. *The Journal of Alternative and Complementary Medicine*, *13*(2), 247-252.

Simpson, D. M., Alexander, D. N., O'brien, C. F., Tagliati, M., Aswad, A. S., Leon, J. M., ... & Monaghan, E. P. (1996). Botulinum toxin type A in the treatment of upper extremity spasticity: a randomized, double-blind, placebo-controlled trial. *Neurology*, *46*(5), 1306-1306.

Smith, S. J., Ellis, E., White, S., & Moore, A. P. (2000). A double-blind placebo-controlled study of botulinum toxin in upper limb spasticity after stroke or head injury. *Clinical rehabilitation*, *14*(1), 5-13.

Snels, I. A., Beckerman, H., Twisk, J. W., Dekker, J. H., De Koning, P., Koppe, P. A., ... & Bouter, L. M. (2000). Effect of triamcinolone acetonide injections on hemiplegic shoulder pain: a randomized clinical trial. *Stroke*, *31*(10), 2396-2401.

Sonde, L., Fernaeus, S. E., Nilsson, C. G., & Viitanen, M. (1998). Stimulation With Low Frequency (1.7 Hz) Transcutaneous Electric Nerve Stimulation (Low-Tens) Increases Motor. *Scand J Rehab Med*, *30*, 95-99.

Staples, M. P., Forbes, A., Green, S., & Buchbinder, R. (2010). Shoulder-specific disability measures showed acceptable construct validity and responsiveness. *Journal of clinical epidemiology*, *63*(2), 163-170.

Steinberg, J. J., & Sledge, C. B. (1983). Synovial factors and chondrocyte-mediated breakdown of cartilage: Inhibition by hydrocortisone. *Journal of orthopaedic research*, *1*(1), 13-21

Stergioulas, A. (2008). Low-power laser treatment in patients with frozen shoulder: preliminary results. *Photomedicine and laser surgery*, *26*(2), 99-105.

Stevens, J. A., & Stoykov, M. E. P. (2003). Using motor imagery in the rehabilitation of hemiparesis. *Archives of physical medicine and rehabilitation*, *84*(7), 1090-1092.

Strasser, E. M., Draskovits, T., Praschak, M., Quittan, M., & Graf, A. (2013). Association between ultrasound measurements of muscle thickness, pennation angle, echogenicity and skeletal muscle strength in the elderly. *Age*, *35*(6), 2377-2388.

Suethanapornkul, S., Kuptniratsaikul, P. S.-a., Kuptniratsaikul, V., Uthensut, P., Dajpratha, P., & Wongwisethkarn, J. (2008). Post Stroke Shoulder Subluxation And Shoulder Pain: A Cohort Multicenter Study. *Medical journal of the Medical Association of Thailand*, 91(12), 1885.

Suputtitada, A., & Suwanwela, N. C. (2005). The lowest effective dose of botulinum A toxin in adult patients with upper limb spasticity. *Disability and rehabilitation*, *27*(4), 176-184.

Suriya-Amarit, D., Gaogasigam, C., Siriphorn, A., & Boonyong, S. (2014). Effect of interferential current stimulation in management of hemiplegic shoulder pain. *Archives of physical medicine and rehabilitation*, *95*(8), 1441-1446.

Tan, G., Jensen, M. P., Thornby, J. I., & Shanti, B. F. (2004). Validation of the Brief Pain Inventory for chronic nonmalignant pain. *The Journal of Pain*, *5*(2), 133-137.

Teoli D, An J. Transcutaneous Electrical Nerve Stimulation (TENS) [Updated 2019 Mar 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2019 Jan-. Available from: https://www-ncbi-nlm-nih-gov.proxy1.lib.uwo.ca/books/NBK537188/

Tepperman, P. S., Greyson, N. D., Hilbert, L., Jimenez, J., & Williams, J. I. (1984). Reflex Sympathetic Dystrophy In Hemiplegia. Archives of physical medicine and rehabilitation, 65(8), 442-447.

Tichelaar, Y. V., Geertzen, J. H., Keizer, D., & Van Wilgen, C. P. (2007). Mirror box therapy added to cognitive behavioural therapy in three chronic complex regional pain syndrome type I patients: a pilot study. *International journal of rehabilitation research*, *30*(2), 181-188.

Topcuoglu, A., Gokkaya, N. K. O., Ucan, H., & Karakuş, D. (2015). The effect of upper-extremity aerobic exercise on complex regional pain syndrome type I: a randomized controlled study on subacute stroke. *Topics in stroke rehabilitation*, *22*(4), 253-261.

Türkkan, C., Öztürk, G. T., Uğurlu, F. G., & Ersöz, M. (2017). Ultrasonographic assessment of neuromuscular electrical stimulation efficacy on glenohumeral subluxation in patients with hemiplegia: a randomized-controlled study. *Turkish Journal of Physical Medicine & Rehabilitation (2587-0823)*, *63*(4).

Turner-Stokes, L., & Jackson, D. (2006). Assessment of shoulder pain in hemiplegia: Sensitivity of the ShoulderQ. *Disability and Rehabilitation*, *28*(6), 389–395. doi: 10.1080/09638280500287692

Turton, A. J., & Britton, E. (2005). A pilot randomized controlled trial of a daily muscle stretch regime to prevent contractures in the arm after stroke. *Clinical Rehabilitation*, *19*(6), 600-612.

Van Bladel, A., Lambrecht, G., Oostra, K. M., Vanderstraeten, G., & Cambier, D. (2017). A randomized controlled trial on the immediate and long-term effects of arm slings on shoulder subluxation in stroke patients. *European journal of physical and rehabilitation medicine*, *53*(3), 400-409.

Van Langenberghe, H. V., & Hogan, B. M. (1988). Degree Of Pain And Grade Of Subluxation In The Painful Hemiplegic Shoulder. *Scand J Rehabil Med*, 20(4), 161-166.

Van Ouwenaller, C., Laplace, P., & Chantraine, A. (1986). Painful Shoulder In Hemiplegia. Arch Phys Med Rehabil, 67(1), 23-26.

Veldman, M. P., Zijdewind, I., Solnik, S., Maffiuletti, N. A., Berghuis, K. M. M., Javet, M., ... & Hortobágyi, T. (2015). Direct and crossed effects of somatosensory electrical stimulation on motor learning and neuronal plasticity in humans. *European journal of applied physiology*, *115*(12), 2505-2519.

Villán-Villán, M. A., Pérez-Rodríguez, R., Martín, C., Sánchez-González, P., Soriano, I., Opisso, E., ... & Gómez, E. J. (2018). Objective motor assessment for personalized rehabilitation of upper extremity in brain injury patients. NeuroRehabilitation, (Preprint), 1-11.

Vural, S. P., Yuzer, G. F. N., Ozcan, D. S., Ozbudak, S. D., & Ozgirgin, N. (2016). Effects of mirror therapy in stroke patients with complex regional pain syndrome type 1: a randomized controlled study. *Archives of physical medicine and rehabilitation*, *97*(4), 575-581.

Wang, C. J. (2012). Extracorporeal shockwave therapy in musculoskeletal disorders. *Journal of orthopaedic surgery and research*, *7*(1), 11.

Wang, R. Y., Chan, R. C., & Tsai, M. W. (2000). Functional electrical stimulation on chronic and acute hemiplegic shoulder subluxation. *American journal of physical medicine & rehabilitation*, *79*(4), 385-394.

Wanklyn, P., Forster, A., & Young, J. (1996). Hemiplegic Shoulder Pain (Hsp): Natural History And Investigation Of Associated Features. *Disability & Rehabilitation*, 18(10), 497-501.

Ward, N. S., Brander, F., & Kelly, K. (2019). Intensive upper limb neurorehabilitation in chronic stroke: outcomes from the Queen Square programme. *J Neurol Neurosurg Psychiatry*, jnnp-2018.

Wei, X., Wang, S., Li, L., & Zhu, L. (2017). Clinical evidence of chinese massage therapy (Tui Na) for cervical radiculopathy: a systematic review and meta-analysis. *Evidence-Based Complementary and Alternative Medicine*, *2017*.

Wilson, J. L., Hareendran, A., Grant, M., Baird, T., Schulz, U. G., Muir, K. W., & Bone, I. (2002). Improving the assessment of outcomes in stroke: use of a structured interview to assign grades on the modified Rankin Scale. Stroke, 33(9), 2243-2246.

Wilson, R. D., Gunzler, D. D., Bennett, M. E., & Chae, J. (2016). Peripheral Nerve Stimulation Compared with Usual Care for Pain Relief of Hemiplegic Shoulder Pain: A Randomized Controlled Trial (vol 93, pg 17, 2014). *American journal of physical medicine & rehabilitation*, *95*(2), E29-E29.

Wilson, R. D., Knutson, J. S., Bennett, M. E., & Chae, J. (2017). The effect of peripheral nerve stimulation on shoulder biomechanics: a randomized controlled trial in comparison to physical therapy. *American journal of physical medicine & rehabilitation*, *96*(3), 191.

Wissel, J., Ganapathy, V., Ward, A. B., Borg, J., Ertzgaard, P., Herrmann, C., ... & Fulford-Smith, A. (2016). OnabotulinumtoxinA improves pain in patients with post-stroke spasticity: findings from a randomized, double-blind, placebo-controlled trial. *Journal of pain and symptom management*, *52*(1), 17-26.

Wittkopf, P. G., & Johnson, M. I. (2017). Mirror therapy: A potential intervention for pain management. *Revista da Associação Médica Brasileira*, *63*(11), 1000-1005.

Wolf, S. L., Catlin, P. A., Ellis, M., Archer, A. L., Morgan, B., & Piacentino, A. (2001). Assessing Wolf motor function test as outcome measure for research in patients after stroke. Stroke, 32(7), 1635-1639.

Wolf, S. L., Thompson, P. A., Morris, D. M., Rose, D. K., Winstein, C. J., Taub, E., ... & Pearson, S. L. (2005). The EXCITE trial: attributes of the Wolf Motor Function Test in patients with subacute stroke. Neurorehabilitation and neural repair, 19(3), 194-205.

Wong, R. A. (1986). High voltage versus low voltage electrical stimulation: force of induced muscle contraction and perceived discomfort in healthy subjects. *Physical therapy*, *66*(8), 1209-1214.

Wu, M. T., Sheen, J. M., Chuang, K. H., Yang, P., Chin, S. L., Tsai, C. Y., ... & Pan, H. B. (2002). Neuronal specificity of acupuncture response: a fMRI study with electroacupuncture. *Neuroimage*, *16*(4), 1028-1037.

Yang, Y. J., Zhang, J., Hou, Y., Jiang, B. Y., Pan, H. F., Wang, J., ... & Cheng, J. (2017). Effectiveness and safety of Chinese massage therapy (Tui Na) on post-stroke spasticity: a prospective multicenter randomized controlled trial. *Clinical rehabilitation*, *31*(7), 904-912.

Yasar, E., Vural, D., Safaz, I., Balaban, B., Yilmaz, B., Goktepe, A. S., & Alaca, R. (2011). Which treatment approach is better for hemiplegic shoulder pain in stroke patients: intra-articular steroid or suprascapular nerve block? A randomized controlled trial. *Clinical rehabilitation*, *25*(1), 60-68.

Yelnik, A. P., Colle, F. M., Bonan, I. V., & Vicaut, E. (2007). Treatment of shoulder pain in spastic hemiplegia by reducing spasticity of the subscapular muscle: a randomised, double blind, placebo controlled study of botulinum toxin A. *Journal of Neurology, Neurosurgery & Psychiatry*, *78*(8), 845-848.

Yoo, S. D., Jung, S. S., Kim, H. S., Yun, D. H., Kim, D. H., Chon, J., & Hong, D. W. (2012). Efficacy of ultrasonography guided stellate ganglion blockade in the stroke patients with complex regional pain syndrome. *Annals of rehabilitation medicine*, *36*(5), 633.

You, Y. Y., Her, J. G., Woo, J. H., Ko, T., & Chung, S. H. (2014). The effects of stretching and stabilization exercise on the improvement of spastic shoulder function in hemiplegic patients. *Journal of physical therapy science*, *26*(4), 491-495.

Young, H. E., Hyeyun, K., & Hee, I. S. (2016). Pamidronate effect compared with a steroid on complex regional pain syndrome type I: Pilot randomised trial. *Acute facial erythema following methotrexate administration; what is your diagnosis?*, *21*, 29.

Zhang, L., Xing, G., Fan, Y., Guo, Z., Chen, H., & Mu, Q. (2017). Short-and long-term effects of repetitive transcranial magnetic stimulation on upper limb motor function after stroke: a systematic review and meta-analysis. *Clinical rehabilitation*, *31*(9), 1137-1153.

Zhao, H., Nie, W., Sun, Y., Li, S., Yang, S., Meng, F., ... & Huang, S. (2015). Warm needling therapy and acupuncture at meridian-sinew sites based on the meridian-sinew theory: hemiplegic shoulder pain. *Evidence-Based Complementary and Alternative Medicine*, *2015*.

Zoons, E., Dijkgraaf, M. G. W., Dijk, J. M., Van Schaik, I. N., & Tijssen, M. A. (2012). Botulinum toxin as treatment for focal dystonia: a systematic review of the pharmaco-therapeutic and pharmaco-economic value. *Journal of neurology*, *259*(12), 2519-2526.

Zorowitz, R. D., Hughes, M. B., Idank, D., Ikai, T., & Johnston, M. V. (1996). Shoulder Pain And Subluxation After Stroke: Correlation Or Coincidence? *The American Journal of Occupational Therapy*, 50(3), 194-201.

Zhou, M., Li, F., Lu, W., Wu, J., & Pei, S. (2018). Efficiency of neuromuscular electrical stimulation and transcutaneous nerve stimulation on hemiplegic shoulder pain: a randomized controlled trial. *Archives of physical medicine and rehabilitation*, *99*(9), 1730-1739.