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CONSERVATIVE TREATMENT OF THE CUBITAL TUNNEL SYNDROME, AN ULNAR NEUROPATHY: A SYSTEMATIC LITERATURE REVIEW

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The purpose of this thesis was to find the current evidence concerning conservative treatment of the cubital tunnel syndrome. Essential theoretical background was firstly provided, consisting of anatomy of the ulnar nerve and cubital tunnel, definition of the cubital tunnel syndrome with typical clinical presentations, examination, diagnostic studies and current treatment methods, both conservative and surgical.

A systematic literature review was then conducted. The search process was carried out in three databases: PubMed, Science Direct and PEDro. Two methodological quality assessment tools, PEDro scale and MINORS, were then applied to the selected studies. Four studies were accepted and shortly summarized in a table. Results were provided and concluded according to current best evidence.

This systematic literature review found that, current evidence suggests that patient education and activity modification is the best available conservative treatment method for mild to moderate cubital tunnel syndrome. Additional nigh time splinting could be considered. However, the current literature does not agree on its positive quantity. Lastly, nerve gliding exercises and steroid injections were not supported currently for the treatment of cubital tunnel syndrome.

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1 INTRODUCTION

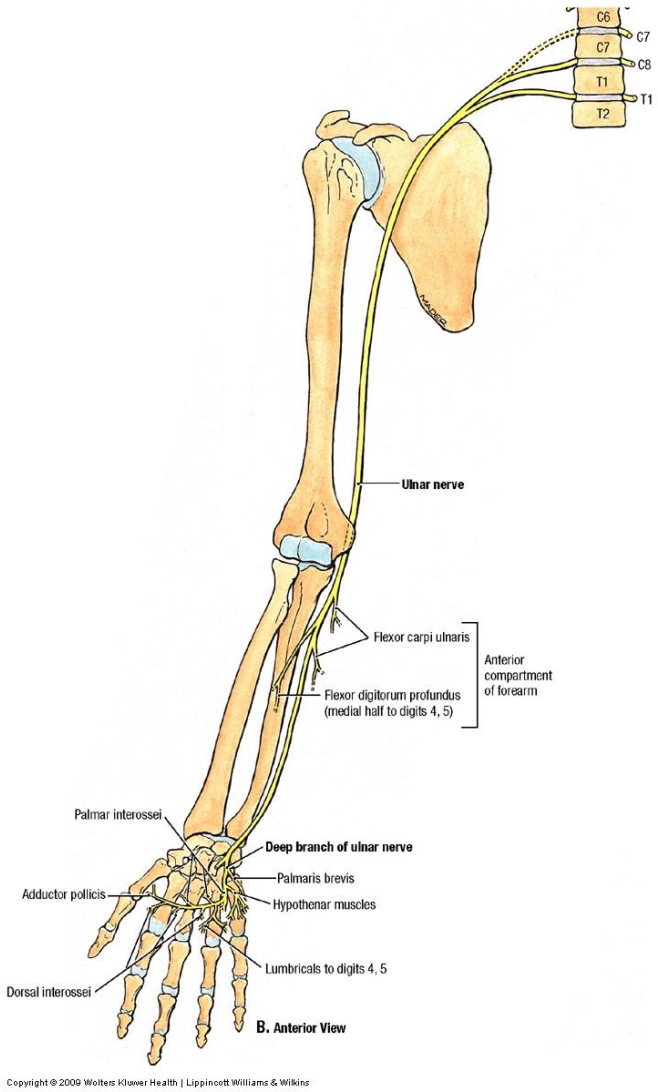
Cubital tunnel syndrome (CuTS) also known as entrapment of the ulnar nerve at the elbow, is the most common ulnar nerve neuropathy. (Andrews, Rowland, Pranjal & Ebraheim 2018, 832). After carpal tunnel syndrome, it is the second most common peripheral nerve compression of the upper extremity (Robertson & Saratsiotis 2005, 345). Treatment recommendations are directed by the severity of the symptoms. Options range from conservative treatment to surgical management. (Andrews et al. 2018, 832.) Conservative treatment is generally considered as the initial line of treatment for patients with mild to moderate symptoms. However, there is a lack of evidence-based literature or guidelines on the conservative treatment to direct physiotherapy practitioners. (Kooner et al. 2019, 75.) Suitable treatment for CuTS is still highly debated due to surgical results of CuTS being relatively less successful than its surgical carpal tunnel counterpart (Kooner et al. 2019, 75). Recent studies have concluded that success rate of improving symptoms of CuTS with surgery is significantly lower at 70% as compared to carpal tunnel release, which has the success rate of more than 90% (Assmus et al. 2015, 23). This has led to the increase in number of surgeons that consider conservative therapy as their first line of treatment, especially with moderate cases (Kooner et al. 2019, 75).

There is an increasing amount of conservative therapy methods to choose from. Widely established treatment methods are patient education and night time splinting. More recently there has been emerging literature and discussion concerning neural mobilization and the established neurodynamics behind it, as a treatment method for peripheral neuropathies. Current literature indicates that there seems to be a considerable role for conservative treatment in CuTS. (Kooner et al. 2019, 75.) This thesis will firstly focus on to the anatomy of the ulnar nerve and the cubital tunnel. Followed by theoretical background of the cubital tunnel syndrome and its current diagnosing and treatment methods. Before conducting a systematic literature review to search the available evidence to conclude the appropriate approach for conservative treatment of CuTS.

2 ANATOMY

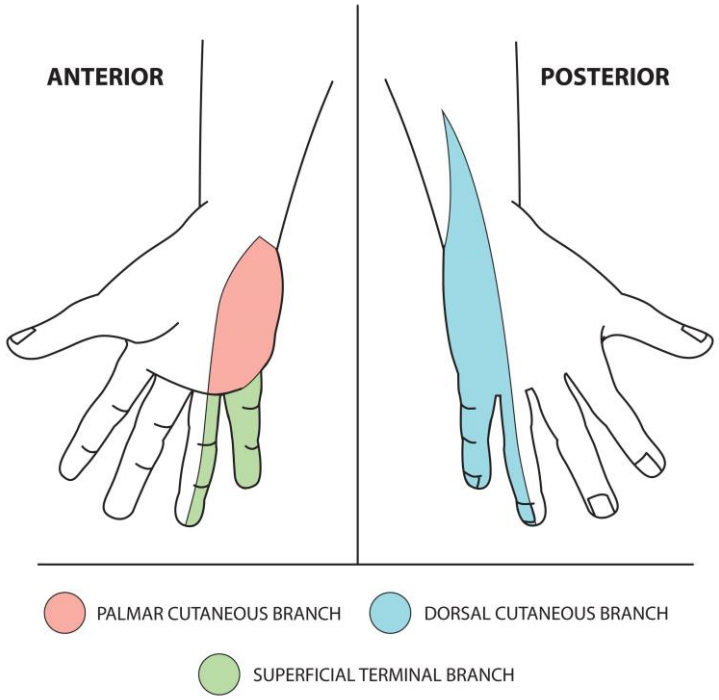
2.1 Anatomy of the ulnar nerve

The ulnar nerve is one of the major peripheral nerves of the upper limb and has both sensory and motor function. It originates from C8 and T1 spinal roots, occasionally receiving fibers from C7 spinal root (Picture 1.). They then form the medial cord of the brachial plexus and descend down the medial aspect of the upper arm in the anterior muscular compartment. The ulnar nerve then transitions to the posterior muscular compartment of the arm, by piercing the medial intermuscular septum. The nerve then proceeds to pass the arcade of Struthers (Picture 3.), one of the possible sites for ulnar nerve entrapment. At the elbow the ulnar nerve passes between the medial epicondyle of humerus and the olecranon process of ulna, going through the cubital tunnel posterior to the medial epicondyle. Entering the forearm, the ulnar nerve goes through the two heads of the flexor carpi ulnaris (FCU) muscle and continues alongside the ulnar bone, staying above the flexor digitorum profundus (FDP) and below the FCU. The ulnar nerve innervates the FCU and the medial half of FDP in the proximal part of the forearm. At the wrist, the ulnar nerve arrives to the palm through the Guyon's canal and divides to superficial and deep branches. (Agur & Dalley 2013, 489; Andrews et al. 2018, 832; Moore & Dalley 2014, 777.)



Picture 1. Anatomy of the ulnar nerve (Agur & Dalley 2013, 488)

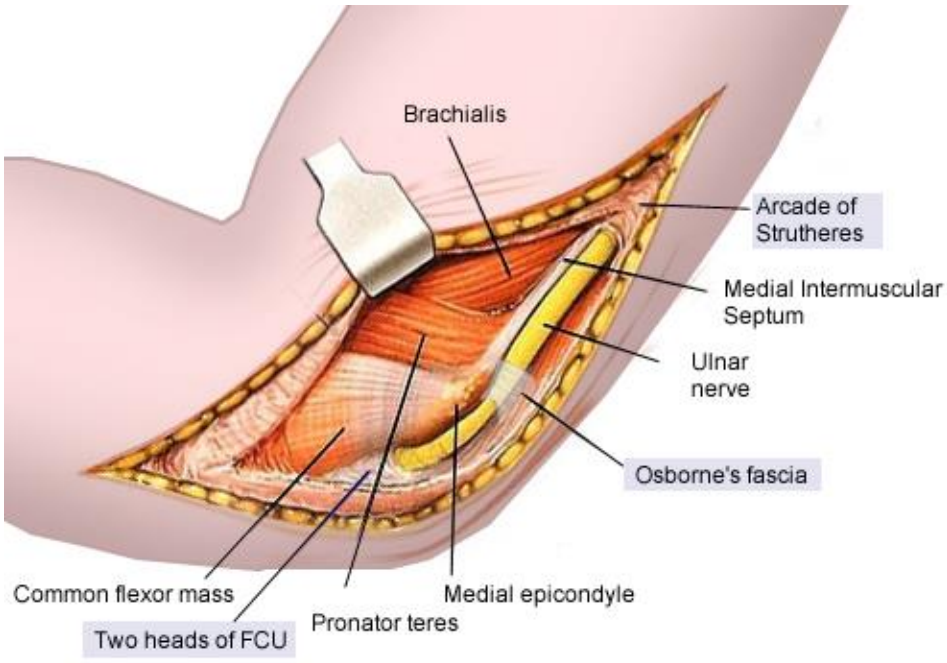
The deep branch of the ulnar nerve innervates majority of the intrinsic muscles of the hand. These consist of interosseous and hypothenar muscles, the medial two lumbricals (3th and 4th digits) and 1½ thenar muscles, deep head of the flexor pollicis brevis and adductor pollicis. (Agur & Dalley 2013, 489.) There are three branches of the ulnar nerve that gives sensory innervation. At the distal part of the forearm, before the Guyon's canal the ulnar nerve gives off two branches, dorsal and palmar cutaneous branches. Dorsal cutaneous branch supplies sensation to the dorsal side of the medial one and half digits (little finger and half of the ring finger) and the palmar cutaneous branch supplies sensation to the palmar surface of medial half of the hand (Picture 2.). The third sensory branch, the superficial branch, arises from the palm itself and supplies palmar surface of the medial one and a half digits (little finger and half of the ring finger). (Agur & Dalley 2013, 489; Andrews et al. 2018, 832.)



Picture 2. Sensory innervation/distribution of the ulnar nerve (Website of Medical Exam Prep 2016)

2.2 Anatomy of the cubital tunnel

The cubital tunnel is a space located in the elbow through which the ulnar nerve passes posterior to the medial epicondyle of the humerus. Cubital tunnel's ceiling is made out of the Osborne's ligament, also known as the cubital retinaculum. This ligament connects between the olecranon process and the medial epicondyle and is a continuation of the facia connecting the two heads of FCU (Picture 3.). The Osborne's ligament also acts as the beginning to the cubital tunnel. The floor of the cubital tunnel is formed by the medial collateral ligament (MCL) and by the elbow joint capsule. The medial epicondyle and the olecranon process act as the walls of the tunnel. (Andrews et al. 2018, 832.)



Picture 3. Anatomy of the cubital tunnel (Website of Ortho Bullets 2019)

3 CUBITAL TUNNEL SYNDROME

3.1 Definition

The term cubital tunnel syndrome (CuTS) indicates a set of symptoms produced by ulnar nerve compression at the elbow. Defining symptoms include both sensory and motor deficits. The compression is located posterior to medial epicondyle where the ulnar nerve traverse under the Osborne's ligament and the proximal fascia of the flexor carpi ulnaris (FCU) muscle. (Assmus et al. 2015, 19; Assmus et al. 2011, 90.)

3.2 Clinical presentation

Ulnar nerve compression can manifest with both sensory and motor deficits. Ranging from transient to permanent symptoms. Usually initial symptoms start as a decrease in sensory function, as the sensory fibers are anatomically more superficial, oppose to the deeper motor fibers (Kelly & Hughes 2013, 233). This sensory reduction, known as paresthesia, can be designated to the cutaneous sensory distribution of the ulnar nerve

(Picture 2.). Presence of motor deficits indicate more sever and later stage/presentation of the nerve compression, alluding to unfavorable prognosis (Andrews et al. 2018, 832; Bradshaw & Shefner 1999, 457). These motor deficits may eventually result in muscular weakening and atrophy, when left untreated (Andrews et al. 2018, 834). Once muscle atrophy has occurred it is largely irreversible (Assmus et al. 2015, 19; Assmus et al. 2011, 94).

As flexion of the elbow compresses the cubital tunnel and increases intraneural pressure of the ulnar nerve, symptoms such as paresthesia is usually provoked and worsen. As such, this presenting/presentation of symptoms can be seen with patients who participate in activities that include constant or repetitive elbow flexion. (Andrews et al. 2018, 834; Svernlöv et al. 2009, 205.) Nighttime symptoms are common among patients, as they often sleep with their elbow flexed (Andrews et al. 2018, 834). This can cause transient paresthesia, consequently waking them up frequently and likely effecting on their quality of sleep (Kelly & Hughes 2013, 233).

Indication of a progressed chronic CuTS include muscle atrophy, clumsiness (frequently dropping items from the hand), weakness especially affecting the 5^{th} and 4^{th} digits. Patients with advanced stage of chronic CuTS may also begin to develop a claw deformity on their hand, caused by the lack of intrinsic muscle strength and conversely uncontested activity of the FDP (Andrews et al. 2018, 834). Flexion of the metacarpophalangeal joints and extension of the interphalangeal joints is thus impaired, causing the clawing of the 4^{th} and 5^{th} digits. These symptoms can negatively impact on patients' daily activities. (Robertson & Saratsiotis 2005, 345.) Patients might not recognize the presence of the neuropathy before the symptoms develop to more severe stages. At which point there might already be developed nerve damage (Andrews et al. 2018, 832).

3.3 Examination

Understanding and identifying the different clinical presentations of CuTS can aid the practitioners to subsequently choose the right examination tests to help them to locate the site of compression and further confirm the diagnosis (Andrews et al. 2018, 832).

The examination should start from the patient's affected arm first, inspecting and palpating the hand to observe any muscular atrophy or aforementioned clawing of the 5th and 4th digits. Secondly, potential subluxation of the ulnar nerve over the medial epicondyle should be checked, moving through the full range of motion with the elbow. Sensation in the distribution of the ulnar nerve should be also be tested (Picture 2.). One method being the two-point discrimination test (Tang & Nellas 2009, 236).

Andrews et al. covered several clinical tests that are used to examine the state of motor function of the ulnar nerve (Table 1.). If there is an evident weakness compared to the contralateral side, ulnar nerve compression is plausible. (Andrews et al. 2018, 834)

Table 1. "Tests for ulnar nerve motor function" (Andrews et al. 2018, 835).

Muscle	Test Instructions	Positive Sign
FCU	Flex wrist in ulnar direction against resistance	Weakness
FDP	Flex DIP of the 5th digit against resistance	Weakness
Abductor digiti minimi	Abduct the 5th digit against resistance	Weakness
1st dorsal interosseous	Abduct 2nd digit against resistance	Weakness
Adductor pollicis	Press tightly a sheet of paper between the thumb and index finger	Froment's sign: IP joint will flex
3rd palmar interosseous	Adduct each finger	Wartenberg's sign: 5th digit will start to abduct relative to other digits

FCU = flexor carpi ulnaris; FDP = flexor digitorum profundus; DIP = distal interphalangeal joint; IP = interphalangeal joint

Tinel's sign and elbow flexion test are commonly used provocative tests. The prior is performed by repeatedly tapping over the cubital tunnel's cutaneous area (commonly known as the funny bone). For a positive sign, radiating sensation, tingling or paresthesia should be produced in the sensory distribution of the ulnar nerve (Picture 2.). (Andrews et al. 2018, 834; Montagna & Liguori 2000, 977.) To perform the elbow flexion test, the patient is requested to fully flex their elbow, while slightly abducting the shoulder. Thus, narrowing the cubital tunnel and the available space for the ulnar nerve. Positive signs include tingling or paresthesia in the sensory distribution of the

ulnar nerve (Picture 2.). Variation of this test may be carried out, by adding wrist flexion in the ulnar direction. This will incorporate the contraction of the FCU muscle to the test which may aggravate the symptoms. (Andrews et al. 2018, 834.)

3.4 Diagnostic studies

Diagnostic studies are able to help establish the diagnosis. Electromyography (EMG) and nerve conduction studies can be used to locate the site of compression and determine the severity of the nerve damage. (Andrews et al. 2018, 834; Bradshaw & Shefner 1999, 457; Folberg, Weiss & Akel-man 1994, 144.) These electrodiagnostic studies can also help to differentiate between segmental demyelination and axonal deterioration (Robertson & Saratsiotis 2005, 345).

Differential diagnoses should be carried out to exclude any other possible explanations for the presented symptoms. These include investigating for, brachial plexopathy/neuropathy, cervical nerve root neuropathology, thoracic outlet syndrome, cubitus valgus, Pancoast tumor, Guyon's canal syndrome and medial epicondyle osteophytes. (Andrews et al. 2018, 834; Folberg, Weiss & Akelman 1994, 136-144). If indicated, radiographs should be considered to be taken of the affected arm and/or cervical spine to exclude bone deformities, soft tissue calcification or arthritic changes that may be producing the ulnar neuropathy (Bradshaw & Shefner 1999, 457). Some metabolic conditions can also predispose to ulnar neuropathies and as such systemic and metabolic conditions should be screened for (Bozentka 1998, 92). Understanding the etiology of the neuropathy, guides the practitioners to determine suitable treatment method (Andrews et al. 2018, 834).

3.5 Treatment methods

3.5.1 Conservative treatment

Recommendations for treatment methods are determined by the severity of the symptoms. Options range from conservative treatment to surgical management (Andrews et

al. 2018, 832). Conservative treatment is normally trialed out first, especially for patients presenting with mild symptoms. Conservative treatment mainly focuses on rehabilitation, alleviating pressure on the nerve, pain relief and reducing inflammation. (Andrews et al. 2018, 834; Kooner et al. 2019, 75.)

Patient education and activity modification is considered to be one of the first things to be included in all treatments of CuTS. It is thought-out to be a simple and effective way to effect on patients' symptoms and treatment outcomes. Patients should be advised to avoid activities that include aggravating elbow positions and repetitive elbow flexion. (Andrews et al. 2018, 834; Kooner et al. 2019, 75.)

Nighttime splinting is a common treatment modality for CuTS. (Andrews et al. 2018, 832). The night splint restricts the elbow to 45° of flexion, were the pressure directed to the ulnar nerve is at its minimum (Andrews et al. 2018, 835; Kooner et al. 2019, 75). It aims to alleviate nighttime pressure to the ulnar nerve as well as eliminate undesirable elbow flexion, which has the opposite effect of increasing stress and pressure to the ulnar nerve (Kooner et al. 2019, 75). Nighttime splinting has been seen to significantly improve symptoms (Assmus et al. 2015, 19).

Nerve mobilization and gliding exercises, also known as neurodynamics have been a relatively new topic when it comes to treating entrapment neuropathies (Kooner et al. 2019, 75). Neurodynamics aims to facilitate normal movement and gliding of the nerve in its surroundings (Basson et al. 2017, 593). However, in a recent meta-analysis Bosson et al. concluded that there is still insufficient evidence to use neurodynamics in the treatment of CuTS and that additional studies are required (Basson et al. 2017, 611). Other implemented conservative treatment methods include, nonsteroidal anti-inflammatory drugs (NSAIDs), corticosteroid (steroid/lidocaine) injections, pulsed ultrasound and laser therapy, which all remain controversial in their treatment benefit (Andrews et al. 2018, 835; Kooner et al. 2019, 75).

3.5.2 Surgery

In case conservative treatment is unsuccessful in preventing progression of CuTS in the duration of several months, surgical treatment might be necessary (Andrews et al. 2018, 856). Surgery may also be indicated if there are initial findings of objective muscle atrophy, as already occurred muscle atrophy is predominantly irreversible (Assmus et al. 2015, 19; Assmus et al. 2011, 94). The purpose of the surgical intervention is to release the ulnar nerve from its compression across the entire cubital tunnel. The exact location of the compression is required before a surgical procedure is proposed (Andrews et al. 2018, 835).

There are three surgical procedures for CuTS, comprising of simple decompression (open surgery or with an endoscope), decompression with ulnar nerve transposition (variations of intramuscular, submuscular or subcutaneous) and medial epicondylectomy (Andrews et al. 2018, 835; Assmus et al. 2011, 94). Simple decompression is performed either with an open procedure or with an endoscope, latter of which has recently being performed to an increasing degree. Although, there has not been any findings of definitive advantages between the two variations. (Assmus et al. 2015, 20.) Nerve transposition on the other hand is a more intrusive/invasive procedure, that requires substantial/considerable amount of interfering to the nerve and the surrounding structures. It is generally reserved for more severe cases of CuTS. There has been no findings to indicate statistically significant difference between the results of simple decompression compared to nerve transposition in numerous meta-analyses and systematic reviews (Assmus et al. 2015, 20). The third surgical procedure is medial epicondylectomy. In the literature, medial epicondylectomy has been recommended for cases were the ulnar nerve has been observed subluxing. However, it is no longer highly regarded as the procedure can destabilize the elbow joint. (Andrews et al. 2018, 835).

4 AIM AND OBJECTIVES OF THE THESIS

The aim of this thesis is to gather the best supported evidence concerning conservative physiotherapy treatment of Cubital Tunnel Syndrome (CuTS) in a form of a systematic literature review. The research question of this systematic review is as follows:

> Based on recent evidence, which conservative treatment methods are most suitable for the treatment of the Cubital tunnel syndrome?

5 RESULTS

5.1 Search strategy

The systematic literature search was completed by a single reviewer. The database search was carried out on the 04.11.2019 and 05.11.2019. The databases PubMed, Science Direct and PEDro were used in the search. The search terms, which were used in the search were “cubital tunnel syndrome” AND “conservative”. Search results for each search term are shown in Table 2.

Table 2. Database search

Entry Terms		PEDro	ScienceDirect	PubMed
Cubital tunnel syndrome	AND conservative	1	897	62
	AND physiotherapy	0	249	30
Total Hits		1	1146	92

5.2 Selection of studies

Figure 1. displays the study selection process. During the search process, studies were screened based on the title and abstract for eligibility. Included studies had to be recent, published in the past 10 years (2009-2019) as well as treat CuTS patients in any form of conservative way. Exclusion criteria included studies that focused on the surgical methods of the CuTS, studies were CuTS was not the subject, case reports, reviews or studies that were not found in English. Case reports were excluded due to their low scientific reliability. The database search produced 1239 results from the three databases. After applying in- and exclusion criteria 5 studies remained. Duplicates were then removed, leaving 3 studies to be included into methodological quality assessment.

Due to the small number of studies found, the reviewer checked a recent (2019) systematic review by Kooner et al. if any relevant studies had not been found in the database search, considering the limitation of its scope. The reference list was gone through with the same inclusion and exclusion criteria as used in the database search. One additional randomized controlled trial (RCT) by vanVeen et al. (2015) was found to be included into the methodological quality assessment.

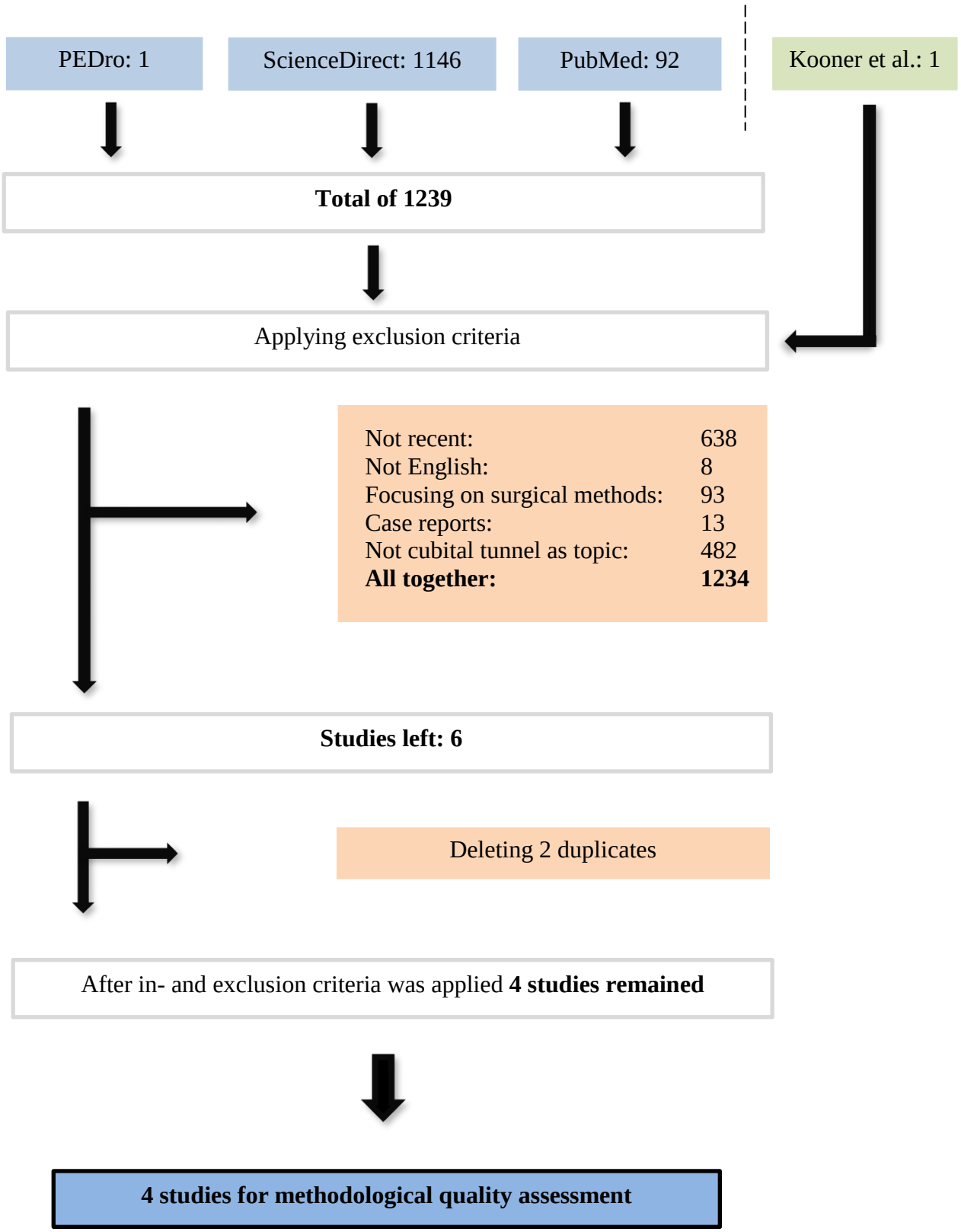


Figure 1. Flow diagram of study selection

5.3 Methodological quality assessment

5.3.1 PEDro scale for randomized controlled trials

Once the search process was completed, a methodological quality assessment tool was applied to assess the quality of the two included randomized controlled trials (RCT). The chosen assessment tool was PEDro scale. PEDro stands for Physiotherapy Evidence Database, which is an open access database with over 45 000 studies in the physiotherapy field of medical science. Admitted trials are rated there using the PEDro scale, which is in short is a check list to determine if a certain criterion was met or not in the report of the trial. PEDro scale evaluates two facets of trial quality, the credibility (or "internal validity") of the trial and secondly if the trial has adequate statistical information so that it can be interpreted. PEDro scale does not consider the "generalisability" (or "external validity") or the "size of treatment effect". The scale uses 11 different criteria. The first criteria, the eligibility criteria, does not contribute to the total score. The full assessment tool can be seen in Appendix 1. The minimum PEDro score, to reach a moderate to high validity, was stated as 6/10. (Website of Physiotherapy Evidence Database 2019.)

PEDro score for Svernlöv et al. was found by the reviewer form the PEDro database and had already been assessed by two separate reviewers. Result of each criterion was separately shown in the website. Svernlöv et al. had received a PEDro scale score of 5/10. (Website of Physiotherapy Evidence Database 2019.) This confirmed score was trusted upon and used in this quality assessment. As the score was already available, the reviewer used this as a practice run for the chosen assessment tool. The result of this practice run was evidently influenced by the previously seen score and was not included in this quality assessment. The reviewer conducted the methodological quality assessment for the second trial, vanVeen et al. which received a total score of 9/10. The result for each criterion can be seen in Table 3.

Table 3. Methodological quality assessment using PEDro Scale

Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Score**
Svernlöv et al. 2009	1	1	1	1	0	0	0	0	0	1	1	5/10
vanVeen et al. 2014	1	1	1	1	1	0	1	1	1	1	1	9/10

Svernlöv et al. received a score of 5/10, which did not cross the score threshold of 6/10 or higher to reach a moderate to high validity. In contrast, vanVeen et al. achieved a score of 9/10, achieving the standard to be considered to have moderate to high validity. For this literature review the reviewer concluded that both of the studies would be accepted.

5.3.2 MINORS for non-randomized studies

As PEDro scale was only applicable for clinical trials, another quality assessment tool was applied for the selected non-randomized studies. In a systematic review and meta-analysis of methodological quality assessment tools for different study designs, Zeng et al. recommended MINORS, methodological quality assessment tool for non-randomized studies (Zeng et al. 2015, 8). The assessment tool has 8 or 12 items, depending if the study being assessed is comparative or non-comparative. Items are scored as such, 0 for “not reported”, 1 for “reported but inadequate” or 2 for “reported and adequate”. For non-comparative studies ideal score was stated as 16 and for comparative studies score of 24. (Slim et al. 2003, 714.) Both of the studies selected were non-comparative. The full assessment tool can be found in Appendix 2. The result for each assessment items can be seen in Table 4.

Table 4. Methodological quality assessment using MINORS

Study	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Score**
Shah et al. 2013.	2	2	2	2	0	2	2	2	14/16
Nakamichi K. 2009.	2	2	2	2	2	2	2	0	14/16

Both of the two studies achieved a score of 14 out of the ideal score of 16. The reviewer concluded that both the studies would be accepted in this literature review. Summary of all of the included studies can be seen below in Table 5.

Table 5. Summary of the included studies.

Title, Author & year of publication	Purpose/Objective	Design	Subjects	Methods	Results	Limitations
Conservative treatment of the cubital tunnel syndrome Svernlöv et al. 2009.	To evaluate the treatment effect of night time splinting, nerve gliding exercises and patient education and activity modification alone with mild to moderate elbow ulnar neuropathy cases.	Randomized Controlled Trial (RCT)	Subjects with clinical symptoms (mild or moderate) of ulnar neuropathy at the elbow. Total of 70 participants, 39 women and 31 men. Mean age of 43 (age range of 17-72). All patients had at least 3-months history of symptoms prior to presentation.	Subject were randomised to three groups. All three groups received initial patient education. Group A used night splints for 3 months. Group B was instructed nerve gliding exercises for every day for 3 months. Group C acted as a control group and did not receive any further intervention apart from the initial patient education. Outcome was measured before treatment and after six months.	All three groups presented with improvements in outcome. Although, the control group with only patient education improved as much as the two intervention groups. No additional benefit was hound with nerve gliding exercises or night time splinting.	For the intervention groups there were no way to measure patient compliance or adherence to the treatment programs. The number of patients was small and as such the results have to be interpreted carefully.
Corticosteroid injection in patients with ulnar neuropathy at the elbow: A randomized, double-blind, placebo-controlled trial vanVeen et al. 2015.	To assess the effectiveness of ultrasound-guided corticosteroid injection with elbow ulnar neuropathy patients.	Randomized Controlled Trial (RCT)	Patients with clinical diagnosis of ulnar neuropathy at the elbow. Total of 55 participants, 28 women and 27 men. Mean age of 55. Patients were recruited between	Total of 55 participants were randomised in to two groups, intervention and placebo. Participants received ether an ultrasound-guided injection (1 ml containing 40 mg methylprednisolone acetate and 10 mg lidocaine	No positive effect was found with ultrasound-guided corticosteroid injection compared to a placebo injection. No significant difference with regarding to the outcome measures were	The study had relatively low number of participants decreasing the statistical power of the study. At a point the study was temporarily paused due to slow recruitment. Included participant had

			September 2009 and April 2014.	hydrochloride) or a placebo injection. Additionally, both groups received patient education, consisting of activity modification advice and information about ulnar neuropathy at the elbow.	found between the two groups.	long duration of symptoms making it uncertain if corticosteroid injections could have benefits in the initial stages of ulnar neuropathy. Measures used in the assessment of primary outcomes had not been verified in terms of ulnar neuropathy.
Outcomes of Rigid Night Splinting and Activity Modification in the Treatment of Cubital Tunnel Syndrome Shah et al. 2013.	To prospectively examine, utilizing validated outcome measures, symptom improvement in subjects with mild to moderate CuTS managed with night time splinting and patient education (activity modification).	Prospective Cohort Study	Prospectively enrolled patients with diagnosed mild or moderate CuTS. Patients were recruited between August 2009 and January 2011. Total of 19 participants (25 extremities), 11 women and 8 men. Mean age of 43 years (range of 21 to 72 years) Average symptom duration of 7 months (range of 1 to 41 months).	Patients were treated using night time splinting (in 45° of elbow flexion) for 3 months along with patient education (activity modification). Follow-up was conducted following the initial 3 months as well as after minimum of 1 year (mean of 2 years) to measure recurrence.	88% of the participants improved significantly by the initial 3-months follow-up and maintained improvements to the final follow-up. 22 out of 24 extremities were successfully managed without the need of a surgery.	The study did not include a control group for a comparison. Patients included in the study were mainly diagnosed with mild CuTS compared to only small representation of four moderate CuTS patients.

Patient Education for the Treatment of Ulnar Neuropathy at the Elbow Nakamichi et al. 2009.	To evaluate the effect of patient education in elbow ulnar neuropathy and determine its indications.	Case study	Subjects with clinical diagnose of ulnar neuropathy at the elbow. Total of 77 participants (80 nerves), of which 67 were office workers (12 women and 55 men), 9 homemakers (all woman) and 1 retired man. One woman and to men were affected bilaterally.	Patients were treated with patient education (explanation of the pathophysiology) and activity modification. Treatment lasted for 3-months. Outcome was measured first time after 3-months and if symptoms were observed to improve, follow-up was extended until at least a year had passed from when the patient had reached a plateau in improvement to examine recurrence.	60% of the nerves measured excellent or good outcome. 80% of the cases with a diagnose of mild degeneration measured excellent or good outcome compared to 38% of the cases with moderate or severe nerve degeneration. Recurrence rate was smaller with mild cases as to severe. Analysis indicated that change in nerve degenerative state correlated with the outcome, while other factors did not: age, sex, effected side, length of the neuropathy, diabetes, subluxation of the nerve or smoking.	Most of the patients had diagnosis of a mild ulnar neuropathy. As such, moderate to severe cases had a small representation and the results of the study should not be applied to this group. Included patient were mainly office workers, thus the effect of the treatment for more physical occupations is still in question. Patient compliance to adhere to the given guidance was not assessed.

5.4 Current evidence-based recommendations for conservative treatment of CuTS

Included RCT study by Svernlöv et al. compared the treatment effect of nighttime splinting and nerve gliding exercises to a control group with only patient education (PE) and activity modification (AM) alone. Both of the intervention groups also received PE and AM. The study found that all groups improved in outcome after 3-months intervention period at the 6-month follow-up. No significant difference was found in outcome improvement between the groups. As a result, no additional benefit was displayed with nighttime splinting and nerve gliding exercises compared to only PE and AM alone. A second study by Shah et al. also assessed the effect of nighttime splinting with the addition of PE and AM, when they prospectively assessed a single cohort. The study found significant improvement with nighttime splinting plus PE and AM in the first 3-month follow-up. Additionally, the minimum of 1 year (mean of 2 years) prospective follow-up found out that 88% of the participant had been successfully treated with conservative treatment without symptom recurrence or the need of a surgery. (Shah et al. 2013; Svernlöv et al. 2009.)

The aforementioned two studies that looked at nighttime splinting presented with differing results and conclusion. Although both studies supported the notion that large number of the patients will respond positively to conservative treatment. They did not agree on the treatment effect of nighttime splinting. (Shah et al. 2013; Svernlöv et al. 2009.)

Patient education (PE) and activity modification (AM) appeared in all of the included studies. It was either separately assessed (Nakamichi et al.) or alongside with a conservative method (Shah et al. and vanVeen et al.) or both, included separately and paired with another treatment (Svernlöv et al.). The contents of the PE and AM stayed largely the same from study to study, comprising of information about the pathophysiology of CuTS and advice on what aggravating activities and movements should be avoided. Shah et al. and vanVeen et al. had PE and AM only as addition to their assessed treatment method (nigh time splinting in the prior and corticosteroid injection in former) and did not assess it separately like the two other included studies. Therefore, the true effect of PE and AM would have been difficult to isolate from these

studies and as such they were not considered regarding to PE and AM in this review. (Nakamichi et al. 2009; Shah et al. 2013; Svernlöv et al. 2009; vanVeen et al. 2015.)

As previously stated in this section, Svernlöv et al. found that PE and AM alone had the same treatment effect as PE and AM with nerve guiding exercises or night time splinting. The study concluded that, PA and AM seem to be successful treating CuTS on its own. Nakamichi et al. assessed the effect of PE and AM alone. The study included a long follow-up time of at least a one 1 year after the patient had stopped improving in outcome. They found out that 66% of the patients had achieved good or excellent outcome and that the recurrence rate of the neuropathy for patients with mild degenerations was less than 5%. According to the studies, patient education and activity modification appear to be effective when treating patient with mild or moderate ulnar neuropathy at the elbow. (Nakamichi et al. 2009; Svernlöv et al. 2009.)

Only one study, Svernlöv et al., looked to the effect of nerve gliding exercises. They did not find any addition benefit when including nerve gliding exercises to PE and AM compared to only PE and AM. Therefore, according to the literature in this review nerve gliding exercises seem to currently carry relatively weak evidence for its use. (Svernlöv et al. 2009.)

Lastly, vanVeen et al. assessed the effect of corticosteroid injection (more commonly known as steroid injection) comparing it to a placebo. The study found no difference between the two groups, overall success rate of the treatments being nearly identical (30% in corticosteroid injection group and 28% in placebo group). According to this study, corticosteroid injection does not have additional benefit compared to a placebo. (vanVeen et al. 2015.)

6 CONCLUSION

The current literature supports the idea that conservative treatment has a positive effect on patients with mild to moderate cubital tunnel syndrome. Patient education and activity modification seem to have the highest support for its use and should be considered as the first treatment option. Other treatment methods such as nighttime splinting can be considered, but the current literature is mixed on its beneficial value. Whereas, nerve gliding exercises and steroid injections remain controversial and display no additional positive effect over placebo.

7 DISCUSSION

7.1 Comparing studies

The two studies that looked at the night time splinting (Svernlöv et al. and Shah et al.) were different in their study methods and direct comparison was being avoided when writing this review. Most notably, one was an RCT and the other a single cohort without a control group to compare the treatment effect to.

As Shah et al. stated in their own discussion section, although both of the studies had similar inclusion criteria for their participants, including mild to moderate ulnar neuropathies at the elbow, the two assessed groups differed from each other at base line. Majority of Shah et al. participants had positive nerve electrodiagnostic studies while majority of Svernlöv et al. participants had normal results. There was also a slight difference with the night time splints between the two studies. Svernlöv had a brace that prevented movement of the elbow over 45° whereas Shah et al. maintained 45° elbow flexion. There was no consensus on the length of the treatment in either of the studies, as both stated that it had not been determined in previous literature. (Shah et al. 2013, 7; Svernlöv et al. 2009.)

Both studies also stated that patient compliance and adherence was an effecting factor in the evaluation of treatment. Patient compliance was measured and reported as high by Shah et al. as whereas patient compliance was not measure by Svernlöv et al. Although, Svernlöv et al. did suggest that patient education, informing patients to avoid excessive elbow flexion, may have motivated their patients to use the night splint. (Svernlöv et al. 2009; and Shah et al. 2013.)

One interesting notion that Svernlöv et al. brought up was the fact that the true treatment effect of patient education and activity modification is hard, if not impossible to isolate. These treatments have become a mainstay in conservative treatment of CuTS and clinical trials have to comply with ethical standard of giving patients suitable treatment. Therefore, as mentioned by Svernlöv et al., it is not certain what amount of the treatment effect of PA and AM is due to normal healing process and how much can be contributed to the treatment itself. (Svernlöv et al. 2009, 205.)

7.2 Learning experiences

There were many learning experiences during the thesis writing process. Most notably the whole process of conducting a systematic literature review for the first time. The literature review process took longer than expected. Particularly reviewing the studies. While the hardest part was undeniably drawing the conclusion from the results on display. Although all the studies corresponded to the research question that was being asked. While writing the conclusion part, I noticed how cautiously I had to proceed when interpreting the results. In that part as it is in research as a whole, complete removal of subjective bias is nearly impossible but should certainly be kept at its minimum. One of the concepts learned from the whole thesis process was the realization that most research questions will not have the highest evidence available to them. Nonetheless, that which is available can be used to make the current best achievable conclusion.

7.3 Limitations of this systematic literature review

There were definitely some limitations to this systematic literature review. For instance, the number of studies in this review was quite low, albeit due to the lack of evidence-based literature in this subject. The conclusion to the research question is expected to change once new studies emerge, as it should. Another limitation was that half of the studies did not include a control/placebo group to compare their treatment effect to. Limiting factors in the studies also included small number of participants and the use of unverified outcome measures.

Secondly, including an additional study from a recent systematic literature review by Kooner et al. seemed unconventional but necessary, due to the small number of studies found during the search process. The addition of the study broadened the subject matter and the amount of treatment methods being reviewed. Admittingly, it may have led to compromising the standard nature of a systematic literature review, as the name implies, as well as introducing possible subjective bias to the review.

Using two separate methodological quality assessment tools made it unfeasible to assess the quality of the studies between the assessment tools. That said, RCTs are normally considered higher in the hierarchy of level of evidence than non-comparative studies (Burns, Rohrich, Chung 2011, 2). Additionally, the final scores from the conducted methodological quality assessments were not confirmed by a second reviewer. Which is a fairly standard procedure in a systematic literature review.

7.4 Future recommendations

It is quite clear that not enough high-quality studies have been conducted concerning conservative treatment of CuTS. Future research is needed to further assess the current treatment methods. More clinical trials should be implemented. Studies should preferably include a control group and a sufficient follow-up time as a part of their study methods.

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PEDro scale

1.	eligibility criteria were specified	no ❑ yes ❑ where:
2.	subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received)	no ❑ yes ❑ where:
3.	allocation was concealed	no ❑ yes ❑ where:
4.	the groups were similar at baseline regarding the most important prognostic indicators	no ❑ yes ❑ where:
5.	there was blinding of all subjects	no ❑ yes ❑ where:
6.	there was blinding of all therapists who administered the therapy	no ❑ yes ❑ where:
7.	there was blinding of all assessors who measured at least one key outcome	no ❑ yes ❑ where:
8.	measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	no ❑ yes ❑ where:
9.	all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat"	no ❑ yes ❑ where:
10.	the results of between-group statistical comparisons are reported for at least one key outcome	no ❑ yes ❑ where:
11.	the study provides both point measures and measures of variability for at least one key outcome	no ❑ yes ❑ where:

The PEDro scale is based on the Delphi list developed by Verhagen and colleagues at the Department of Epidemiology, University of Maastricht (*Verhagen AP et al (1998). The Delphi list: a criteria list for quality assessment of randomised clinical trials for conducting systematic reviews developed by Delphi consensus. Journal of Clinical Epidemiology, 51(12):1235-41*). The list is based on "expert consensus" not, for the most part, on empirical data. Two additional items not on the Delphi list (PEDro scale items 8 and 10) have been included in the PEDro scale. As more empirical data comes to hand it may become possible to "weight" scale items so that the PEDro score reflects the importance of individual scale items.

The purpose of the PEDro scale is to help the users of the PEDro database rapidly identify which of the known or suspected randomised clinical trials (ie RCTs or CCTs) archived on the PEDro database are likely to be internally valid (criteria 2-9), and could have sufficient statistical information to make their results interpretable (criteria 10-11). An additional criterion (criterion 1) that relates to the external validity (or "generalisability" or "applicability" of the trial) has been retained so that the Delphi list is complete, but this criterion will not be used to calculate the PEDro score reported on the PEDro web site.

The PEDro scale should not be used as a measure of the "validity" of a study's conclusions. In particular, we caution users of the PEDro scale that studies which show significant treatment effects and which score highly on the PEDro scale do not necessarily provide evidence that the treatment is clinically useful. Additional considerations include whether the treatment effect was big enough to be clinically worthwhile, whether the positive effects of the treatment outweigh its negative effects, and the cost-effectiveness of the treatment. The scale should not be used to compare the "quality" of trials performed in different areas of therapy, primarily because it is not possible to satisfy all scale items in some areas of physiotherapy practice.

Last amended June 21st, 1999

APPENDIX 1

Notes on administration of the PEDro scale:

All criteria	**Points are only awarded when a criterion is clearly satisfied**. If on a literal reading of the trial report it is possible that a criterion was not satisfied, a point should not be awarded for that criterion.
Criterion 1	This criterion is satisfied if the report describes the source of subjects and a list of criteria used to determine who was eligible to participate in the study.
Criterion 2	A study is considered to have used random allocation if the report states that allocation was random. The precise method of randomisation need not be specified. Procedures such as coin-tossing and dice-rolling should be considered random. Quasi-randomisation allocation procedures such as allocation by hospital record number or birth date, or alternation, do not satisfy this criterion.
Criterion 3	*Concealed allocation* means that the person who determined if a subject was eligible for inclusion in the trial was unaware, when this decision was made, of which group the subject would be allocated to. A point is awarded for this criteria, even if it is not stated that allocation was concealed, when the report states that allocation was by sealed opaque envelopes or that allocation involved contacting the holder of the allocation schedule who was "off-site".
Criterion 4	At a minimum, in studies of therapeutic interventions, the report must describe at least one measure of the severity of the condition being treated and at least one (different) key outcome measure at baseline. The rater must be satisfied that the groups' outcomes would not be expected to differ, on the basis of baseline differences in prognostic variables alone, by a clinically significant amount. This criterion is satisfied even if only baseline data of study completers are presented.
Criteria 4, 7-11	*Key outcomes* are those outcomes which provide the primary measure of the effectiveness (or lack of effectiveness) of the therapy. In most studies, more than one variable is used as an outcome measure.
Criterion 5-7	*Blinding* means the person in question (subject, therapist or assessor) did not know which group the subject had been allocated to. In addition, subjects and therapists are only considered to be "blind" if it could be expected that they would have been unable to distinguish between the treatments applied to different groups. In trials in which key outcomes are self-reported (eg, visual analogue scale, pain diary), the assessor is considered to be blind if the subject was blind.
Criterion 8	This criterion is only satisfied if the report explicitly states *both* the number of subjects initially allocated to groups *and* the number of subjects from whom key outcome measures were obtained. In trials in which outcomes are measured at several points in time, a key outcome must have been measured in more than 85% of subjects at one of those points in time.
Criterion 9	An *intention to treat* analysis means that, where subjects did not receive treatment (or the control condition) as allocated, and where measures of outcomes were available, the analysis was performed as if subjects received the treatment (or control condition) they were allocated to. This criterion is satisfied, even if there is no mention of analysis by intention to treat, if the report explicitly states that all subjects received treatment or control conditions as allocated.
Criterion 10	A *between-group* statistical comparison involves statistical comparison of one group with another. Depending on the design of the study, this may involve comparison of two or more treatments, or comparison of treatment with a control condition. The analysis may be a simple comparison of outcomes measured after the treatment was administered, or a comparison of the change in one group with the change in another (when a factorial analysis of variance has been used to analyse the data, the latter is often reported as a group × time interaction). The comparison may be in the form hypothesis testing (which provides a "p" value, describing the probability that the groups differed only by chance) or in the form of an estimate (for example, the mean or median difference, or a difference in proportions, or number needed to treat, or a relative risk or hazard ratio) and its confidence interval.
Criterion 11	A *point measure* is a measure of the size of the treatment effect. The treatment effect may be described as a difference in group outcomes, or as the outcome in (each of) all groups. *Measures of variability* include standard deviations, standard errors, confidence intervals, interquartile ranges (or other quantile ranges), and ranges. Point measures and/or measures of variability may be provided graphically (for example, SDs may be given as error bars in a Figure) as long as it is clear what is being graphed (for example, as long as it is clear whether error bars represent SDs or SEs). Where outcomes are categorical, this criterion is considered to have been met if the number of subjects in each category is given for each group.

APPENDIX 2

Table 2. The revised and validated version of MINORS

Methodological items for non-randomized studies	Score†
1. **A clearly stated aim:** the question addressed should be precise and relevant in the light of available literature 2. **Inclusion of consecutive patients**: all patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion) 3. **Prospective collection of data**: data were collected according to a protocol established before the beginning of the study 4. **Endpoints appropriate to the aim of the study**: unambiguous explanation of the criteria used to evaluate the main outcome which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis. 5. **Unbiased assessment of the study endpoint**: blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise the reasons for not blinding should be stated 6. **Follow-up period appropriate to the aim of the study**: the follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events 7. **Loss to follow up less than 5%**: all patients should be included in the follow up. Otherwise, the proportion lost to follow up should not exceed the proportion experiencing the major endpoint 8. **Prospective calculation of the study size**: information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes *Additional criteria in the case of comparative study* 9. **An adequate control group**: having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data 10. **Contemporary groups**: control and studied group should be managed during the same time period (no historical comparison) 11. **Baseline equivalence of groups**: the groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results 12. **Adequate statistical analyses**: whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk	

†The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). The global ideal score being 16 for non-comparative studies and 24 for comparative studies.