SYSTEMATIC REVIEW

Test procedures and positive diagnostic criteria of the upper limb tension tests differ: a systematic review of the DiTA database

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Abstract

Background: The validity of the ULTT is unclear, due to heterogeneity of test procedures and variability in the definition of a positive test

Objective: To evaluate test procedures and positive diagnostic criteria for the upper limb tension test (ULTT) in diagnostic test accuracy studies.

Methods: A systematic review of diagnostic accuracy studies was performed. We conducted a search of the DiTA (Diagnostic Test Accuracy) database and selected primary studies evaluating the diagnostic accuracy of the ULTT. We assessed risk of bias, performed data extraction on study characteristics, test procedures, and positive diagnostic criteria, and performed a descriptive analysis.

Results: We included nine studies (681 participants), four diagnosing people with cervical radioculopathy (CR), four diagnosing people with carpal tunnel syndrome (CTS), and one included both CR and CTS. The risk of bias varied between 2 and 6 out of 6 positive items. Eight studies reported on the ULTT\textsubscript{1} (median nerve).

Overall, all studies clearly described their test procedures and positive diagnostic criteria although the order of movements and the diagnostic criteria between studies varied. We suggest a more standardised test procedure for the ULTT\textsubscript{1} to consist of: 1) stabilising the shoulder in abduction, 2) extending the wrist/fingers, 3) supinating the forearm, 4) externally rotating the shoulder, 5) extending the elbow, and finally 6) performed structural differentiation by side bending (lateral flexion) of the neck. This proposed test procedure should reproduce the symptoms and enables the clinician to evaluate whether symptoms increase/decrease when stressing or relaxing the nerves.

Keywords: Diagnostic accuracy; Positive diagnostic criteria; Positivity threshold; Systematic review; Test procedures; Upper limb tension test

Declarations: This work has not been published previously, or is under consideration for publication elsewhere.

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Introduction
Upper limb tension tests (ULTT), also called upper limb neurodynamic tests (ULNT), are a commonly used neurodynamic technique by clinicians to evaluate nerve gliding and neural tension in patients. Neurodynamic tests aim to investigate if a peripheral nerve is contributing to the patients’ pain, resulting in peripheral neuropathic pain, by moving and stretching the peripheral nerves. When utilizing a neurodynamic test, the assessor manipulates the limb into various positions with the aim of increasing tension on peripheral nerves. The positioning of each joint is added to provoke the pain or reproduce the symptoms.

Variations of the ULTT aim to selectively differentiate between nerves of the upper limb by altering the type of movement and movement sequence. The ULTT1 and 2a aim to test the median nerve, the ULTT2b the radial nerve, and ULTT3 the ulnar nerve. The ability of the ULTT to selectively test specific nerve roots is however questionable.

The diagnostic strategy to diagnose a compression of the nerve includes, apart from clinical signs and symptoms and tests like the ULTT, electromyography, nerve conduction studies, and MRI (magnetic resonance imaging). Clinicians often use the ULTT to help diagnose whether a patient has peripheral neuropathic pain, like cervical radiculopathy (CR), carpal tunnel syndrome, or cubital tunnel syndrome.

Before any test can be endorsed for use in clinical practice, its validity needs to be determined. Systematic reviews state that the validity of the ULTT is unclear, due to heterogeneity of test procedures and variability in the definition of a positive test. Positive test criteria (positivity thresholds) used in literature and clinical practice include, among others, reproduction of patient symptoms with differences between sides, relief or exacerbation of symptoms on structural differentiation, and reproduction of neurological pain associated with the nerve distribution.

Today no current uniform set of positive diagnostic criteria exists for the ULTT, creating uncertainty on what constitutes a positive test. Positive test criteria (positivity thresholds) used in literature and clinical practice include, amongst others, reproduction of patient symptoms with differences between sides, relief or exacerbation of symptoms on structural differentiation, and reproduction of neurological pain associated with the nerve distribution.

Current systematic reviews focus on the accuracy data, irrespective of the test procedures and variation in positive diagnostic criteria. Given that there is a lack of test procedure standardization and there are no clear cut-offs for positive tests available, it brings into question the usefulness of these tests in clinical practice and the validity of the accompanying accuracy data. The establishment of a standardized procedure and clear positive diagnostic criteria needs to be done first before we evaluate the diagnostic accuracy of these tests. When the diagnostic accuracy is established and the ULTT can rule in or rule out patients with a possible CR or CTS, these tests might have greater clinical application and improve patient outcomes. Additionally, this may lead to a reduction in patient waiting time for nerve conduction studies or expensive diagnostic imaging. Therefore, this study aimed to evaluate test procedures and positive diagnostic criteria for the ULTT in diagnostic test accuracy studies and to construct a proposed set of recommended test procedures and positivity thresholds.

Methods
Study design
A systematic review using the DiTA (Diagnostic Test Accuracy) database was performed. DiTA database is a comprehensive index, which is updated monthly using automated searches, of diagnostic test accuracy studies developed specifically for the discipline of physical therapy. It is a sister database of the PEDro (Physiotherapy Evidence Database) which includes intervention studies within the physical therapy domain. We registered our protocol on the UTS (University of Technology Sydney) data repository, and it can be requested from the corresponding author.

Search strategy
The search was conducted on the 22 November 2021 using the search terms: Upper Limb Tension Test and associated synonyms, like ULTT, ULNT, Brachial Plexus Tension, Elvey Test, Upper limb nerve tension test, Peripheral neuropathic pain, Cervical radiculopathy, Carpal tunnel syndrome, Cubital tunnel syndrome.

Study selection
The inclusion criteria consisted of a) adult participants (18 years or over) who present with signs and symptoms that indicate upper limb pathology, b) evaluated sensitivity and/or specificity of the ULTT in diagnosing upper limb pathology by comparing the ULTT to any reference test, c) primary diagnostic test accuracy studies. We excluded studies using non-human subjects or cadavers and where the ULTT was used in combination with other special tests for diagnosis. The eligibility of each study, identified by the search or included in (systematic) reviews, was determined by two out of five independent assessors (GB, CB, CA, HD, SF). Discrepancies were resolved by consensus or by a third independent investigator (AV).

Risk of bias assessment
The QUADAS-2 is the recommended tool to assess risk of bias (RoB) in diagnostic test accuracy studies. As this tool is
rather difficult to administer for clinicians/researchers, we simplified it to six criteria (Table 1). Each criterion can be scored yes/no/unclear. Two out of five assessors (GB, CB, CA, HD, SF) independently assessed each study and any discrepancies were discussed and resolved by consensus. If a consensus could not be reached, a third independent investigator (AV) made a final decision.

### Data extraction

Two of five assessors (GB, CB, CA, HD, SF) extracted the following data from each of the studies: author(s) and year of publication, participant details (number, mean age and range, sex, clinical characteristics), examination details (clinical setting, examiner profession and expertise), reference standard, test procedures, and criteria for positive test result, e.g. pain, range of motion (either actively or passively performed). Discrepancies and a data check was done by two review authors (HB, AV).

### Analysis

We considered a specificity or sensitivity value high enough to be clinically useful in ruling in or out a condition, according to the SpPIn (specificity high and positive test rules in a condition) and SnNOut (sensitivity high and negative test rules out a condition) rules. As most diagnostic test accuracy studies are performed in highly specific populations, generalising their accuracy to the public requires sensitivity and specificity to be sufficiently high, with recommended cut-offs between 0.85 and 0.90–0.95 being used. We conducted a frequency analysis of the number of papers outlining the test protocol used for the ULTT to determine the common denominator of those procedures. Similarly, a descriptive analysis was completed to assess the positive diagnostic criteria.

### Results

### Search results

From the initial search in the DiTA database, 22 original studies were retrieved, in addition to two systematic reviews and three narrative reviews. After reviewing the primary research papers included in these reviews and removing duplicates, we retrieved an additional 5 references, resulting in 27 papers being available for full-text review (Fig. 1). After the application of the selection criteria, we excluded three papers as these were narrative reviews, three papers did not evaluate the ULTT, and one was in a population with low back pain. Finally, we included 10 papers reporting on 9 studies.

### Description of included studies

**Participants.** Four studies aimed at diagnosing CR (386 participants), and four studies aimed at diagnosing CTS in 295 participants. One study (in two publications) included both patients with CR and CTS (Table 2). Individuals with CR were all referred to a specialized clinic or a neurosurgery department. Three out of the four studies on patients with CR specifically stated they included consecutive patients. The average age of the participants varied between 43.2 and 54.3 years and most of the participants were female (varying between 49 and 83%).

**Index test.** The most evaluated test was ULTT1; five studies only evaluated the ULTT1, two studies evaluated all four ULTT tests and provided accuracy data for all tests separately, and one study did not specify which ULTT was evaluated, and one study evaluated the ULTT-A (which was like the ULTT1) and ULTT-B (an alternative to ULTT1). The CR studies reported history taking and physical examination to be part of the reference test, and in two (out of four) studies the reference test was performed by one specialist, while none of the CTS studies did so.

**Reference test.** Nerve conduction study was the most common reference test mainly in the studies investigating CTS, followed by clinical presentation and magnetic resonance imaging (MRI), in the studies investigating CR. The CR studies reported history taking and physical examination to be part of the reference test, and in two (out of four) studies the reference test was performed by one specialist, while none of the CTS studies did so.

**Accuracy data.** All studies provided data on the accuracy of the ULTT, and eight studies reported data for the ULTT1. Based on the sparsity of data related to other ULTT tests, we only report outcomes for the ULTT1. Sensitivity of the four test procedures for the ULTT1 for CR varied between 0.35 and 0.83, and the specificity varied between 0.40 and 0.76, meaning none met the lowest cut-off mentioned in literature of 0.85. For CTS studies, which reported on eight test procedures, reported sensitivity was between 0.06 and 0.93 and specificity between 0.10 and 0.93. In three procedures the accuracy data met at least the 0.85 cut-off, but not the 0.95.

**Risk of bias.** The RoB varied from 2 to 6 criteria scored positive (Table 3).
The page contains a discussion section of a study on diagnostic test procedures. The text discusses the variety of test procedures and criteria used, and proposes a standardised approach. The page also includes a PRISMA flow diagram.
Table 2  Characteristics of included studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Index test</th>
<th>Reference test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cervical radiculopathy</strong></td>
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<tr>
<td>Apelby-Albrecht 2013</td>
<td>Cervical Radiculopathy; (n = 51) consecutive, referred to neurosurgeon; age: 51 (25–67); female: 27 (53%)</td>
<td>ULTT all combined and 1, 2A-B, 3 separate (manual therapists)</td>
<td>Combination of history, clinical examination, and MRI (neurosurgeons)</td>
</tr>
<tr>
<td>Sweden</td>
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</tr>
<tr>
<td>Ghasemi 2013</td>
<td>Cervical Radiculopathy; (n = 97) referred to specialised diagnostic centre; age: 46.3; female: 72 (74.2%)</td>
<td>ULTT (trained examiners)</td>
<td>Nerve conduction studies (EDX) (neurologist)</td>
</tr>
<tr>
<td>Iran</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grondin 2021</td>
<td>Cervical Radiculopathy; (n = 85) consecutive, referred to neurosurgery department; age: 44; female: not reported?</td>
<td>ULTT 1, 2A-B, 3 (one experienced physical therapist)</td>
<td>Combination of history, clinical examination, and MRI (one experienced neurosurgeon)</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleijser-Koehorst 2020</td>
<td>Cervical Radiculopathy; (n = 134), consecutive, referred to specialised clinic; age: 49.9 (10.7); female: 66 (49%)</td>
<td>ULTT1 (physical therapist)</td>
<td>Clinical presentation + MRI (neurosurgeon)</td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
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<tr>
<td><strong>Carpal Tunnel Syndrome</strong></td>
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<td></td>
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<tr>
<td>Bueno-Garcia 2016</td>
<td>Carpal Tunnel Syndrome; (n = 58); age: 54.3 (14.5); female: 44 (75.8%)</td>
<td>ULTT1 (physical therapist)</td>
<td>NCS (neurophysiologist)</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
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<tr>
<td>Trillos 2018</td>
<td>Carpal Tunnel Syndrome; (n = 118) (230 wrists); age: 50.5 (18–86); female: 98 (83.1%)</td>
<td>ULTT1 (physical therapist)</td>
<td>NCS (physiatrist)</td>
</tr>
<tr>
<td>Colombia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vanti 2011</td>
<td>Carpal Tunnel Syndrome; (n = 44); age: 46.3 (10.8); female: 33 (75%)</td>
<td>ULTT1 (physical therapist)</td>
<td>NCS (experienced tester)</td>
</tr>
<tr>
<td>Vanti 2012</td>
<td>Carpal Tunnel Syndrome; (n = 47) (84 limbs); age: 45.9 (10.7); female: 35 (74.5%)</td>
<td>ULTT1 (physical therapist)</td>
<td>NCS (experienced tester)</td>
</tr>
<tr>
<td><strong>Mixed population</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Wainner 2003*/ 2005</td>
<td>(N = 82): Cervical Radiculopathy; (n = 19); age: 43.2 (11.7) Carpal Tunnel Syndrome; (n = 28); age: 48.4 (± 11.5) Female: 41 (50%)</td>
<td>ULTT-A, ULTT-B</td>
<td>NCS (physiatrist or neurologist); needle EMG</td>
</tr>
</tbody>
</table>

Data are mean (standard deviation), mean (range), or frequency (proportion). CTS, carpal tunnel syndrome; EDX, electro diagnostic studies; EMG, electromyography; MRI, magnetic resonance imaging; NCS, nerve conduction study; ULTT, upper limb tension test (ULTT1 and 2A aim to test the median nerve, the ULTT2B the radial nerve and ULTT3 the ulnar nerve).

* data presented from the 2003 paper.

Table 3  Risk of bias assessment.

<table>
<thead>
<tr>
<th>Study</th>
<th>Consecutive or random sample</th>
<th>No inappropriate exclusions</th>
<th>Index and reference test assessed independently</th>
<th>Clear threshold for positive test</th>
<th>All participants received both test</th>
<th>Timing between tests is appropriate</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apelby-Albrecht 2013</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>4</td>
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<tr>
<td>Bueno-Garcia 2016</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>4</td>
</tr>
<tr>
<td>Ghasemi 2013</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, 1 hr</td>
<td>6</td>
</tr>
<tr>
<td>Grondin 2021</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Unlear</td>
<td>4</td>
</tr>
<tr>
<td>Sleijser-Koehorst 2020</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Unclear</td>
<td>4</td>
</tr>
<tr>
<td>Trillos 2018</td>
<td>Yes</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, 20 min</td>
<td>5</td>
</tr>
<tr>
<td>Vanti 2011</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, 20–30 min</td>
<td>6</td>
</tr>
<tr>
<td>Vanti 2012</td>
<td>Yes</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes, 20–30 min</td>
<td>5</td>
</tr>
<tr>
<td>Wainner 2003/2005</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>5</td>
</tr>
<tr>
<td>Study</td>
<td>Step 1</td>
<td>Step 2</td>
<td>Step 3</td>
<td>Step 4</td>
<td>Step 5</td>
<td>Step 6</td>
<td>Step 7</td>
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<tr>
<td><strong>Cervical radiculopathy</strong></td>
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<tr>
<td>Apelby-Albrecht 2013</td>
<td>Shoulder depression</td>
<td>Shoulder abduction, 110°</td>
<td>Wrist and finger extension</td>
<td>Forearm supination</td>
<td>Shoulder external rotation</td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
</tr>
<tr>
<td>Ghasemi 2013</td>
<td></td>
<td>Should abduction</td>
<td></td>
<td>Wrist extension</td>
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<tr>
<td>Grondin 2021 (Nee et al. 2012)</td>
<td>Wrist extension</td>
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<tr>
<td>Sleijser-Koehorst 2020</td>
<td>Shoulder fixation</td>
<td>Shoulder abduction, 90°</td>
<td>Forearm supination</td>
<td>Wrist and finger extension</td>
<td>Shoulder external rotation</td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
</tr>
<tr>
<td><strong>Carpal tunnel syndrome</strong></td>
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</tr>
<tr>
<td>Bueno-Garcia 2016; (Shacklock 2005)</td>
<td>Contralateral flexion of the neck</td>
<td>Shoulder abduction</td>
<td></td>
<td></td>
<td></td>
<td>Elbow extension</td>
<td>Release of cervical lateral flexion</td>
</tr>
<tr>
<td>Trillos 2018</td>
<td>Starting position: 90° shoulder abduction + 90° shoulder external rotation + 90° elbow flexion + forearm supination + maximum extension of wrist and fingers + abduction of the thumb</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
</tr>
<tr>
<td>Vanti 2011 (Butler 2000)</td>
<td>Shoulder stabilisation</td>
<td>Shoulder abduction, 110°</td>
<td>Wrist and finger extension</td>
<td>Forearm supination</td>
<td>Shoulder external rotation</td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
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<tr>
<td>Vanti 2012</td>
<td>Shoulder stabilisation</td>
<td>Shoulder abduction</td>
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<td>Shoulder external rotation</td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
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<tr>
<td><strong>Mixed population</strong></td>
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<tr>
<td>Wainner 2003 / 2005 (ULTT-A)</td>
<td>Shoulder depression</td>
<td>Shoulder abduction</td>
<td>Forearm supination, wrist and finger extension</td>
<td>Shoulder external rotation</td>
<td>Elbow extension</td>
<td>Contra/ipsi-lateral cervical lateral flexion</td>
<td></td>
</tr>
</tbody>
</table>
diagnostic criteria are reproduction of the symptoms and an increase or decrease of symptoms when stressing or relaxing the nerves.

Comparison with existing literature

Previously, several reviews evaluating the ULTT concluded that there is a lack of a clear definition of terms (‘investigators definition of a positive test’) and procedures for the ULTT. The authors all concluded that the validity of ULTT1 is probably hampered by the diversity in the procedure and interpretation of the index test. The major online support tools also use a variety of procedures in their videos, which reflects the variability in test procedures found in the literature and hampers clear implementation.

Proposed set of test procedures and positive diagnostic criteria

Overall, all studies stabilised the shoulder in abduction, extended the elbow, supinated the forearm, extended the wrist, and performed structural differentiation by side bending of the neck, although the order of movements varied. We propose a more standardised test procedure to consist of these movements. The suggested order is like the one performed in the studies with the lowest risk of bias (score of 6): 1) stabilising the shoulder in abduction, 2) extending the wrist/fingers, 3) supinating the forearm, 4) externally rotate the shoulder, 5) extending the elbow, and 6) structural differentiation by laterally flexing (i.e., side bending) the neck. This proposed test procedure aims to assess whether the patient’s symptoms are reproduced and whether symptoms increase or decrease when increasing or decreasing the tension on the nerves.

Strengths and limitations

To our knowledge, this is the first systematic review evaluating the test procedures and positive diagnostic criteria of the ULTT1 in patients with neck or arm pain. A possible limitation of our review may exist in the search strategy, which was conducted solely in the DITA database. DITA is updated monthly, drawing on automated optimised searches of MEDLINE, EMBASE, CINAHL, and the Cochrane Database of Systematic Reviews. Therefore, we consider the DITA database up to date and when we performed a search in PubMed (January 2022) we did not find any additional or missed studies. Another limitation may be present in the study selection, as patients selected in the included studies are specific patients, referred to specialised clinics. Although this finding probably does not influence test
procedures and positive diagnostic criteria, it might influence the accuracy data as these are dependent on prevalence of the condition. Concerning the reference test, in the CR studies it included physical examination in three of the four studies, potentially leading to risk of confirmation bias that might result in higher accuracy data. In two CR studies it was also unclear whether the index and reference test were performed independently. Our findings, however, did not show higher accuracy data in the CR studies, therefore we believe that confirmation bias might not have played an important role. Another limitation could be our risk of bias tool. We used a simpler 6 item ‘checklist’ for risk of bias assessment, to allow clinicians and students to conduct risk of bias assessments more easily. We are confident that the outcomes of the risk of bias assessment will not differ much from the QUADAS-2. We registered our protocol on the UTS data repository only, as we were unable to register the protocol in Prospero which focuses on systematic reviews with a patient related/relevant outcome. Lastly, due to the limited data, we were only able to make recommendations about the ULTT1, and not the ULTT2 (a and b) and ULTT3.

Implications

Clinical implications. We proposed a standardised test procedure and positive diagnostic criteria for use in clinical practice. A more standardised set of test procedures will help clinicians as it is a consistent message to patients. Reproduction of symptoms and a decrease of symptoms when reducing the tension are the recommended criteria for a positive test.

Research implications. We suggest that future research should validate our proposed set of test procedures as well as our proposed set of positive diagnostic criteria. This may lead to greater consistency and standardisation between studies, reducing heterogeneity regarding treatment effectiveness studies, systematic reviews, and meta-analysis of test accuracy studies.

Conclusion

Although the ULTT continues to be used by clinicians, its diagnostic accuracy remains uncertain. Given the ULTT is likely to remain in use by clinicians, we have provided a recommendation on the test protocol, based on the nine studies we found, which includes: 1) stabilising the shoulder in abduction, 2) extending the wrist/fingers, 3) supinating the forearm, 4) externally rotating the shoulder, 5) extending the elbow, and 6) performing structural differentiation by lateral flexion (side bending) of the neck aiming to reproduce the symptoms and enabling the clinician to evaluate whether symptoms increase or decrease when stressing or relaxing the nerves.

Author contributions

APV Conceptualization; APV Data curation; All Formal analysis; NA Funding acquisition; all Investigation; APV, DA Methodology; APV, DA, HB Project administration; APV Resources; APV, DA Software; APV, DA Supervision; APV, DA, MH Validation; all Writing; APV, DA, MH Review & editing

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgement

Georgia Bisset (GB), Christian Blanda (CB), Cassandra Armentino (CA), Helen Dickson (HD), Sarah Fensom (SF) for their assistance in the data extraction.

References

13. Clinical physio: https://www.youtube.com/watch?v=PQI.


