Ulnar Nerve Neurodynamic Test: Study of the Normal Sensory Response in Asymptomatic Individuals

Differentiating the body tissues involved in musculoskeletal pain disorders is a key component of the clinical evaluation. Neural tissue involvement can be evaluated through tests that assess its physiological and mechanical capabilities.1-3 Those tests, known as neurodynamic tests, consist of a sequence of movements aimed to stress different parts of the nervous system.4-7,16,19,22,35 Neurodynamic tests are considered to be able to detect increased nerve mechanosensitivity.12,13,15,19,22,33 This heightened sensitivity in response to mechanical stimuli has been attributed to local inflammatory processes within the nerve1,4,10,14,22 that are specifically related to its connective tissue.22

When determining whether the result of a neurodynamic test is suggestive of increased nerve mechanosensitivity and therefore relevant to current patient complaints, it is important to consider several factors.7 First, a test response that differs from a response that would be considered normal (found in asymptomatic individuals) in terms of the location and intensity of symptoms and the nature of the response may be a sign of neural tissue involvement.23,26,30,38 Second, an asymmetry in the neurodynamic response of the symptomatic versus the asymptomatic side (assumed healthy) in terms of joint angle, pain, and/or muscular resistance to movement may also be relevant, although some authors attribute less importance to this finding.6,13,26 Finally, recent evidence asserts that a positive upper-limb neurodynamic test should at least partially reproduce the patient’s symptoms, and structural differentiation should change these symptoms.28 This latter definition of a positive upper-limb neurodynamic test has been shown to be reliable when used clinically.26

©2014 Lluch Girbés, Department of Physical Therapy, Faculty of Physiotherapy, University of Valencia, C/Gascó Oliag, 5. 46010 Valencia, Spain. E-mail: enrique.lluch@uv.es
Neurodynamic tests frequently cause neural responses in asymptomatic individuals that are considered normal. Normal responses have been previously investigated in the upper limb for the median upper-limb neurodynamic test (ULNT1) and the radial upper-limb neurodynamic test (ULNT2B). For the lower limb, the slump test and the femoral nerve test have also been previously studied in healthy individuals. Currently, to our knowledge, no study has documented the normal responses of the ulnar upper-limb neurodynamic test (ULNT3). In a case report described by Shacklock, an association between improvement of the ULNT3 response and a decrease in symptoms was found in a patient with surgically confirmed ulnar neuropathy.

To apply and interpret the results of a neurodynamic test in patients, clinicians should have a clear understanding of the normal/typical response to the test when applied in an asymptomatic population. The aim of this study was therefore to document normal responses of the ULNT3 in asymptomatic individuals. Our hypothesis was that gender and/ or arm dominance would influence the results of the neurodynamic test. Reliability of findings, based on 2 repeated measurements of the ULNT3, was also established.

**METHODS**

**Study Design**

This was a cross-sectional study designed to document and analyze normal sensory responses to the ULNT3 in asymptomatic individuals. The study was conducted at the research laboratory of the University CEU Cardenal Herrera from January to May 2013.

**Participants**

Individuals between 18 and 50 years of age, with no previous or current symptoms in the cervical region or the upper limbs, were invited to participate in the study. Potential participants were excluded if any of the following was present: a positive Spurling test, neurological signs, range-of-motion limitation in any of the movements required to perform the ULNT3, cervical spine or upper-limb surgery, or a score greater than 4 on the Beighton hypermobility scale. A score higher than 4/9 on the Beighton scale is considered an indicator of generalized joint hypermobility. Hypermobile individuals were excluded to avoid potential confounding results when trying to interpret sensory responses with the ULNT3 in the general population.

Ten participants (5 men, 5 women) were initially recruited to assess repeatability of the shoulder abduction angle during the ULNT3. Their mean ± SD age (range) was 25 ± 4 years (22-36 years). For the primary study, 68 potential volunteers were recruited through advertisements distributed at the University CEU Cardenal Herrera, Valencia, Spain. Eleven of these were excluded, based on refusal to participate (n = 2) and not meeting the inclusion and exclusion criteria (n = 9). Fifty-seven participants (29 women, 28 men), with a mean ± SD age of 27 ± 8 years, were included in the study (FIGURE 1). Fifty-two participants were right-hand and 5 left-hand dominant. Arm dominance was defined as the hand they typically used to write.

The study was conducted following the ethical requirement established in the Helsinki Declaration of 1964 and the sixth revision of 2008. All participants read an information leaflet and signed an informed-consent form before starting the study. The study was approved by the Research Ethics Committee of the University CEU Cardenal Herrera, Valencia, Spain.

**Procedures**

Preliminary to the primary component of the study, intrarater reliability of the shoulder abduction angle measurement during the ULNT3 was determined. Shoulder abduction angle measurement was performed on 10 healthy individuals by a researcher who only participated in this phase of the study. The ULNT3, as described below, was performed twice on each upper limb, with 30 seconds between repetitions. For each repetition, the shoulder was abducted to the point of pain tolerance, defined as the point at
which the participant was too uncomfortable to continue with the test, and the abduction angle was recorded.

After completion of all testing for reliability data, the primary component of the study, which consisted of documenting and analyzing normal responses to the ULNT3, was conducted. Participants were initially screened by a researcher who collected demographic data and determined eligibility to participate, based on inclusion and exclusion criteria. Participants who met the inclusion criteria were subsequently provided with an explanation of the study procedures and instructions regarding the information they should provide during the ULNT3. The same researcher who provided this information, an experienced physical therapist with 2 years of postgraduate training in manual therapy, then performed the ULNT3. The same researcher performed the testing on both sides in all participants. Each arm was tested in random order.

The ULNT3 was performed following a standardized sequence of movement described by Butler: (1) wrist and finger extension, followed by (2) forearm pronation, (3) elbow flexion, (4) shoulder external rotation, (5) scapular depression, (6) shoulder abduction, and (7) cervical contralateral sidebending. The starting position for the test was also standardized, so that participants remained supine without a pillow (thus avoiding any initial neural tension resulting from a flexed cervical spine), their arms alongside their bodies, and legs straight.

The neurodynamic test was performed slowly, and participants were instructed to indicate the point at which they began to perceive a sensory response of tingling, pricking, numbness, burning, or similar sensation (ie, point of onset of symptoms), until the participant indicated that it was too uncomfortable to continue with the movement (point of pain tolerance). Participants were asked to rate their pain at the point of pain tolerance using a numeric rating scale, on which 0 represented “no symptoms” and 10 “the most intense pain imaginable.” Shoulder abduction angle was then recorded at that point. The goniometric measurement of shoulder abduction during the ULNT3 was performed using a digital goniometer (Baseline; Fabrication Enterprises Inc, White Plains, NY). The reliability and validity of the digital goniometer have been previously demonstrated. For shoulder abduction angle measurement, the center of the goniometer was placed on the acromion, the fixed arm parallel to the sternum, and the end of the mobile arm and its extension on the medial epicondyle (FIGURE 2).

Finally, participants were asked to remember the quality and distribution of their symptoms at the point of pain tolerance so that they could report this information once the test was concluded. As in previous studies, the distribution of symptoms was collected with the help of a body map, on which participants marked the location of symptoms or sensory response perceived. To describe the quality or nature of perceived symptoms, participants had to choose between the following descriptors: stretching, pain, tingling, pricking, numbness, burning, or a combination of these. Participants could also write different descriptors in an additional section provided for that purpose. The variables measured with the ULNT3 were pain intensity, shoulder abduction angle, and quality and distribution of symptoms, all of them at the point of pain tolerance.

Statistical Analysis
Data from this study were analyzed using SPSS Statistics Version 19.0 (IBM Corporation, Armonk, NY). The reliability of shoulder abduction angle measurements was calculated with an intraclass correlation coefficient (ICC). Normal distribution of the data was assessed by means of the Kolmogorov-Smirnov test (P>0.05). The influence of sex and hand dominance on pain intensity and shoulder abduction angle was analyzed using a 2-way, repeated-measures analysis of variance, with sex as the between-subject variable and hand dominance as the within-subject variable. The dependent variables were pain intensity, shoulder abduction angle, and the quality and distribution of symptoms, and were all recorded at the point of pain tolerance. Sex and hand dominance were considered independent variables. The assumption of the homogeneity of variance was checked using the Levene test, the sphericity was assumed not to have more than 2 levels, and the assumption of covariance matrices was analyzed using the Box statistic, with a criterion of P>0.001. In the case of statistical significance, a Bonferroni correction was applied.

Quality of symptoms was classified into 7 dichotomous categories for the purpose of statistical analysis: stretching, pain, tingling, pricking, numbness, burning, and other. To analyze the distribution of symptoms, the body chart was divided into 21 areas summarizing the distribution frequency of the participants’ symptoms (FIGURE 3), in which 0 was the minimum possible frequency (if nobody reported symptoms for this area) and 57 was the maximum possible frequency (if all participants reported symptoms for a specific area). Statistical analysis was performed with a 95% confidence interval (CI), considering significant those values with \( P<0.05 \). All participants completed the study.

**RESULTS**

The reliability of shoulder abduction angle measurement with the ULNT3 was ICC = 0.94 (95% CI: 0.84, 0.98) for the dominant side and ICC = 0.92 (95% CI: 0.71, 0.97) for
There was no statistically significant interaction between hand dominance and sex for any of the dependent variables. There were no statistically significant main-effect differences in hand dominance for any variable but shoulder abduction angle measurement, which was higher in the nondominant side (mean, 106.3°; 95% CI: 98.6°, 113.9°) compared to the dominant side (99.7°; 95% CI: 91.9°, 107.4°), a difference of 6.6° (95% CI: 1.1°, 12.1°; P = .02).

There were also significant sex main-effect differences in pain intensity and shoulder abduction angle at the point of pain tolerance of the ULNT3. Pain intensity was higher in women (mean, 7.3; 95% CI: 6.6, 8.0) compared to men (5.6; 95% CI: 4.9, 6.3; P = .01). Shoulder abduction angle was higher in men (mean, 116.3°; 95% CI: 106.1°, 126.6°) compared to women (89.6°; 95% CI: 79.5°, 99.7°; P < .01) (TABLE 1).

Most participants (52.6% for the dominant side, 54.4% for the nondominant side) reported the onset of symptoms in the first phase of the ULNT3 (ie, with wrist and finger extension) (TABLE 2). The point of pain tolerance was most often reached in the final phases of the ULNT3 (shoulder abduction, 50.9% in the dominant side and 43.9% in the nondominant side; contralateral cervical lateral flexion, 38.6% in the dominant side and 50.9% in the nondominant side) (TABLE 3).

The descriptors of the quality of symptoms more often used by participants were stretching (91.2% in the dominant side, 89.5% in the nondominant side) and pain (57.9% in both the dominant and nondominant sides) (TABLE 4). Symptoms or sensory responses were principally located in the medial forearm, followed by the rest of the forearm and hand region. Less commonly, participants also reported symptoms in the arm, shoulder, neck, and axillary regions (FIGURE 3). Frequencies of sensory response location are presented in TABLE 4.

### DISCUSSION

To the best of our knowledge, this is the first study to describe and establish normal responses of the ULNT3 in asymptomatic individuals, as has been previously done for the ULNT1,26 ULNT2A,26 and ULNT2B.27 As hypothesized, the responses to the ULNT3 were influenced by sex and hand dominance. In addition, measurement of shoulder abduction angle when applying the ULNT3 was considered a reliable outcome measure, as an ICC greater than 0.8 is indicative of good reliability.24

These results are consistent with those of a previous study conducted for other neurodynamic tests,27 except for the effect of hand dominance, which had no impact in a previous study.5 Differences between studies in terms of methodology (number of test repetitions5) or characteristics of the sample might have contributed to those differences. For instance, scapular depression, which was one component (phase 5) of the sequence for the ULNT3, was recently shown to have a meaningful impact on the ULNT1 performed in healthy, asymptomatic individuals.25

In this study, although the difference in shoulder abduction angle between the dominant arm (mean, 99.7°; 95% CI: 91.9°, 107.4°) and nondominant arm (106.3°; 95% CI: 98.6°, 113.9°) was statistically significant, it may not be clinically significant, as this 6° difference is close to what would be considered measurement error. Lohkamp and Small26 also did not find clinically relevant side-to-side differ-
ence in joint angle; however, in contrast to the current study, they reported greater values for the dominant arm. Covill and Petersen, who calculated the amount of difference needed to consider asymmetry beyond measurement error, established that a 21° side-to-side difference would be needed for the ulnar nerve biased test. Due to conflicting results in the literature regarding the influence of hand dominance and its relevance to interpretation of neurodynamic tests, further research in this area is needed to provide clearer recommendations to clinicians.

Our results contrast those of previous studies of other neurodynamic tests, which found no influence of sex in joint angle or sensory response. In our study, women demonstrated more pain and less shoulder abduction angle than men during the application of the ULNT3. This finding may be related to evidence that women may experience, in general, more pain during clinical and experimental procedures compared to men. Specifically, the mean perceived pain intensity at the point of pain tolerance measured with the numeric rating scale was 1.6 and 1.9 points higher in women than in men for the dominant side and nondominant side, respectively. However, as this difference was less than 2 points, it may not be clinically significant. In contrast, differences in shoulder abduction angle between men and women were 27.3° and 26.1° for the dominant and nondominant sides, respectively.

Most participants reported the onset of symptoms during phase 1 of the ULNT3 (wrist and finger extension) for both arms. However, it cannot be determined whether the nature of the response was musculoskeletal or neural. As the ulnar nerve is only subjected to low stress in phase 1, symptoms were more likely to be related to mechanical stress of the local musculoskeletal structures of the forearm. Petersen et al also reported the onset of symptoms in the first phase of the ULNT2B, though in a group of individuals with radial nerve pathology.

The point of pain tolerance occurred in the majority of participants (ie, both limbs, 90%-95%) in phases 6 (shoulder abduction) and 7 (cervical contralateral sidebending) of the ULNT3. Given the asymptomatic status of the participants, it is reasonable that most of them completed the final stages of testing. Unlike Lohkamp and Small, who used cervical contralateral flexion and its effects on shoulder abduction angle for the purpose of structural differentiation, in the current study it was only used to further increase tension on the neural tissue in those participants for whom shoulder abduction was not sufficient to reach the point of pain tolerance.

The results of this study, in regard to symptom descriptors, are consistent with those of other studies, with stretching being the most commonly reported symptom, followed by pain. These symptoms are not predominantly neurogenic (ie, pins and needles, burning, tingling). Therefore, the source of sensory response with the application of the ULNT3 might not be solely neural tissue. The lack of neurogenic responses in our study may be due to the fact that we examined asymptomatic individuals, in whom neural tissue was assumed to be healthy. Sensation perceived from other tissues (ie, musculotendinous structures) could have therefore determined the point of pain tolerance. Furthermore, the most common location of symptoms for the ULNT3 was the anteromedial side of the forearm, which corresponds with the area of ulnar nerve distribution and is consist-

### TABLE 3
**Frequency of the Stage at Which Symptom Points of Tolerance Were Reported to Occur During the Ulnar Upper-Limb Neurodynamic Test***

<table>
<thead>
<tr>
<th>Stage</th>
<th>Point of Tolerance of Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist and finger extension</td>
<td>Dominant Arm: 0 (0)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 0 (0)</td>
</tr>
<tr>
<td>Forearm pronation</td>
<td>Dominant Arm: 0 (0)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 0 (0)</td>
</tr>
<tr>
<td>Elbow flexion</td>
<td>Dominant Arm: 0 (0)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 0 (0)</td>
</tr>
<tr>
<td>Shoulder external rotation</td>
<td>Dominant Arm: 4 (70)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 2 (3.5)</td>
</tr>
<tr>
<td>Scapular depression</td>
<td>Dominant Arm: 2 (3.5)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 1 (1.8)</td>
</tr>
<tr>
<td>Shoulder abduction</td>
<td>Dominant Arm: 29 (50.9)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 25 (43.9)</td>
</tr>
<tr>
<td>Contralateral cervical lateral flexion</td>
<td>Dominant Arm: 22 (38.6)</td>
</tr>
<tr>
<td></td>
<td>Nondominant Arm: 29 (50.9)</td>
</tr>
</tbody>
</table>

*Values are frequency (%).

### TABLE 4
**Frequency of Sensations Reported Through the Ulnar Upper-Limb Neurodynamic Test***

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dominant Arm</td>
<td>Nondominant Arm</td>
</tr>
<tr>
<td>Stretching</td>
<td>89%</td>
<td>89%</td>
</tr>
<tr>
<td>Pain</td>
<td>39%</td>
<td>43%</td>
</tr>
<tr>
<td>Tingling</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Pricking</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Numbness</td>
<td>11%</td>
<td>4%</td>
</tr>
<tr>
<td>Burning</td>
<td>14%</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*Each participant could report more than 1 sensation.
tent with that previously proposed for the ULNT3.3,7,34,36

Finally, the results of this study provide further evidence that a variety of sensory responses occur during the performance of neurodynamic tests in asymptomatic individuals.38 Therefore, pain perception is not necessarily suggestive of neural tissue involvement. Reproduction of the patient’s symptoms and modification of those symptoms with structural differentiation may be necessary for a positive interpretation of an upper-limb neurodynamic test.29

Limitations
The ULNT3 has been described in the literature based on a variety of movement sequences. The selection of the specific sequence used in this study was based on the need to measure shoulder abduction angle and Butler’s description of the test.7 Recent literature suggests that the order in which the movements of the neurodynamic test are introduced can influence the responses obtained with the test.34 Accordingly, a different sequence of test components could have produced different results from those obtained in our study. The shoulder abduction angle achieved at the end of the ULNT3 might be considered a reflection of the pain tolerance of the participants, which is influenced by many individual characteristics and external stimuli. Therefore, the willingness of participants to tolerate more pain before deciding that they were “too uncomfortable to continue” might have influenced the results.

Neither average shoulder abduction angle before commencing the test nor the average cervical sidebending angle at the point of pain tolerance was recorded. In addition, reflective of clinical practice, the maximum amount of shoulder abduction achieved before incorporating cervical sidebending varied among participants, as it was based on the maximum angle that could be achieved while maintaining the alignment of the upper extremity. Gathering this information, as Petersen et al30 did for the radial nerve, would have been beneficial to establish additional normal values for the ULNT3.

CONCLUSION

This study describes the sensory responses of asymptomatic individuals resulting from the ULNT3. Those responses differed based on the sex of the participants and, to a lesser extent, hand dominance. Most commonly, the sensory response in healthy participants occurred in the area of ulnar nerve distribution (medial forearm region), and the nature of the response was mainly a stretch and pain sensation. These results can be used for clinical reasoning by clinicians using the ULNT3.●

KEY POINTS

FINDINGS: When performing the ULNT3, the sensory responses of asymptomatic individuals differ based on sex and, to a lesser extent, hand dominance. Most commonly, the sensory response in healthy participants occurred in the area of ulnar nerve distribution (medial forearm region), and the nature of the response was mainly a stretch and pain sensation.

IMPLICATIONS: Clinically, the results of this study should be considered when interpreting the response of patients when the ULNT3 is performed.

CAUTION: The sequence of movement used to perform the ULNT3 used in this study is not universally used. As asymptomatic individuals were tested, interpretation of these results for a symptomatic population must be exercised with caution.

REFERENCES


FIGURE 3. Body chart divided into 21 areas in which sensory response was felt during the ulnar upper-limb neurodynamic test.