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## Diagnostic accuracy of patient interview items and clinical tests for cervical radiculopathy

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### Abstract

**Objective** To determine the diagnostic accuracy of patient interview items and clinical tests to diagnose cervical radiculopathy.

**Design** A prospective diagnostic accuracy study.

**Participants** Consecutive patients ( $N = 134$ ) with a suspicion of cervical radiculopathy were included. A medical specialist made the diagnosis of cervical radiculopathy based on the patient's clinical presentation and corresponding Magnetic Resonance Imaging findings. Participants completed a list of patient interview items and the clinical tests were performed by a physiotherapist.

**Main outcome measures** Diagnostic accuracy was determined in terms of sensitivity, specificity, and positive (+LR) and negative likelihood ratios (−LR). Sensitivity and specificity values  $\geq 0.80$  were considered high. We considered +LR  $\geq 5$  and −LR  $\leq 0.20$  moderate, and +LR  $\geq 10$  and −LR  $\leq 0.10$  high.

**Results** The history items 'arm pain worse than neck pain', 'provocation of symptoms when ironing', 'reduction of symptoms by walking with your hand in your pocket', the Spurling test and the presence of reduced reflexes showed high specificity and are therefore useful to increase the probability of cervical radiculopathy when positive. The presence of 'paraesthesia' and 'paraesthesia and/or numbness' showed high sensitivity, indicating that the absence of these patient interview items decreases the probability of cervical radiculopathy. Although most of these items had potentially relevant likelihood ratios, none showed moderate or high likelihood ratios.

**Conclusions** Several patient interview items, the Spurling test and reduced reflexes are useful to assist in the diagnosis of cervical radiculopathy. Because there is no gold standard for cervical radiculopathy, caution is required to not over-interpret diagnostic accuracy values.

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**Keywords:** Validity; Orthopaedics; Cervicobrachialgia; History taking; Physical examination; Radicular pain

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## Introduction

Compression of a cervical nerve root can lead to a variety of signs and symptoms, including radicular pain and radiculopathy [1–3]. Radicular pain refers to the pain that occurs as a consequence of inflammation and/or compression of a cervical nerve root [3–5]. Radicular pain is considered a mixed pain condition, in which somatic referred pain and neuropathic pain intertwine [2]. Radiculopathy refers to objective neurological deficits, such as sensory deficits (e.g., sensory loss or paraesthesia), motor deficits (e.g., motor weakness) and/or reflex changes [3,5,6]. In the literature however, the term radiculopathy is often used in a broader context, referring to all signs and symptoms that can occur due to nerve root compression, encompassing both radiculopathy and radicular pain [3,4,7]. This is sometimes referred to as radicular syndrome [8–10].

Currently, there are no agreed criteria to diagnose cervical radiculopathy (as in the broader context) [11]. The diagnosis cervical radiculopathy is most commonly based on clinical signs and symptoms that concur with nerve root compression identified via medical imaging (e.g., Magnetic Resonance Imaging (MRI) or computer tomography) [4]. The clinical examination usually includes physical examination, such as provocation and reduction tests, and a clinical neurological examination [1,7,12]. The diagnostic accuracy of various clinical tests for cervical radiculopathy has recently been summarised in two systematic reviews [7,12]. One systematic review concluded that there is evidence that a positive Spurling test, a positive Arm squeeze test and a positive Cervical distraction test are valid clinical tests to increase the likelihood of cervical radiculopathy, based on a high specificity [7]. A negative Arm squeeze test and a combination of negative Upper limb neurodynamic tests (ULNTs) were considered the most accurate clinical tests to decrease the likelihood of cervical radiculopathy [7]. The other systematic review revealed evidence that the Spurling test and the ULNTs can be used to decrease the likelihood of cervical radiculopathy, due to their high sensitivity [12]. The conclusions of both reviews were however preliminary because: (1) the execution of the clinical tests in the original studies differed and were interpreted according to different diagnostic criteria; (2) the sample sizes and total number of patients were relatively small; (3) pooling of data was hampered due to the use of different reference tests (e.g., medical imaging, electromyography, clinical signs and symptoms, and combinations thereof); and (4) the number of studies with a low risk of bias was low [1,7,12].

Although there is only limited evidence for clinical tests, even less is known about the diagnostic accuracy of the patient interview to diagnose cervical radiculopathy. A recent systematic review [13] on the diagnostic accuracy of interview items for cervical radiculopathy could only include two studies [14,15]. The authors concluded that shoulder or scapular pain, and a decrease of symptoms with neck movements are

the patient interview items that are most indicative of cervical radiculopathy [13]. They reported high specificity values for neck pain, arm pain, pain that is constant over time and sensory loss [13]. However, these symptoms are not pathognomonic for cervical radiculopathy and also occur regularly in other common conditions, such as non-specific neck pain [16] and shoulder pain [17]. Because of the limited number of studies available, a call for more diagnostic accuracy studies on patient interview items was expressed [13].

In summary, recent systematic reviews conclude that more studies are needed to evaluate the diagnostic value of clinical tests [12] and patient interview items [13] to diagnose cervical radiculopathy. Therefore, this study aimed to estimate the diagnostic accuracy of plausible patient interview items and clinical tests to diagnose cervical radiculopathy.

## Material and methods

### Design

A diagnostic accuracy study was conducted, in accordance with the STARD guidelines [18]. Data were collected prospectively. The study was approved by the Medical Ethics Committee of the Elisabeth Amphia Hospital in Tilburg, The Netherlands (METC-2013-02). All participants provided written informed consent prior to participating.

### Participants

Consecutive patients with neck and/or arm pain who were referred by their general practitioner or medical specialist to a multidisciplinary clinic with a suspicion of cervical radiculopathy were eligible to participate. Patients were included if they were at least 18 years old and had a sufficient understanding of the Dutch language to complete the questionnaires. Patients with self-reported serious cervical pathology (e.g., malignancies, (rheumatoid) arthritis, fractures or myelopathy), neurological conditions (e.g., multiple sclerosis), diabetes mellitus, complex regional pain syndrome, polyneuropathy or a history of spinal surgery were excluded.

### Reference standard

Two criteria had to be met for the diagnosis of cervical radiculopathy: (1) a neurosurgeon had to diagnose the patient with cervical radiculopathy based on the clinical presentation of the patient (i.e., presence of radicular pain and/or a neurological deficit, such as numbness, muscle weakness or altered reflexes, relevant to a cervical radiculopathy); and (2) a MRI scan had to confirm nerve root compression or irritation at a relevant segmental level (i.e., the same or adjacent level) on the ipsilateral side [19].

### *Index tests*

#### *Patient interview items*

Due to a lack of evidence on the diagnostic accuracy of patient interview items for cervical radiculopathy, we held a focus group meeting to determine which interview items should be included in the study. The focus group consisted of two physiotherapists, a neurosurgeon and an orthopaedic surgeon. All members of the focus group had extensive (i.e., >10 years) clinical experience in the management of patients with cervical radiculopathy, and were affiliated to various types of institutions (i.e., a multidisciplinary primary health-care clinic, physiotherapy practice, hospital and university). Common interview items, such as the duration of symptoms, presence and intensity of neck and arm pain, provocation or reduction of symptoms with specific movements of the neck or arm, and the presence of paraesthesia, numbness and muscle weakness were included. An overview of all patient interview items is provided in Appendix 1. A list of the selected interview items was created for data collection.

#### *Clinical tests*

The selection of clinical tests was primarily based on the current literature. Additionally, the focus group expressed that the tests had to be easy to perform in clinical practice and reflect a plausible theoretical rationale. The clinical examination consisted of the Spurling test, Upper limb neurodynamic test for the median nerve (ULNT1), Shoulder abduction relief test, the Cervical distraction test and a clinical neurological examination (sensation, reflexes and muscle tests). All clinical tests were performed by an experienced musculoskeletal physiotherapist. An overview of the clinical tests and their operational definitions is provided in Appendix 2.

#### *Procedures*

The patient interview and the clinical tests were performed prior to the reference standard to ensure that the patient who completed the patient interview list and the physiotherapist who performed the clinical tests were both blinded to the final diagnosis. The physiotherapist was blinded to the answers on the patient interview list. The medical specialist who reached the clinical diagnosis and the radiologist who assessed the MRI were blinded to the answers on the patient interview list and results of the clinical tests. The radiologist was aware that the patients were suspected of having cervical radiculopathy. The maximum timeframe between the MRI and the index tests was 2 hours. The clinical medical diagnosis was obtained within 1.5 weeks following the MRI, patient interview and clinical examination.

#### *Statistical analyses*

##### *Sample size*

Based on a sensitivity and specificity of 0.80, a prevalence of 50%, a z-score of 1.96, a marginal error of 0.10 and an

attrition rate of 10%, a sample size of approximately 135 participants was required [7,20,21].

##### *Missing values*

In case of unclear or missing test results, patients were excluded from the analyses for that specific interview item or clinical test.

##### *Diagnostic accuracy*

A two-by-two table was constructed in which the index test results were plotted against the results from the reference standard. Diagnostic accuracy was calculated in terms of the sensitivity, specificity, and positive and negative likelihood ratios (LR) with 95% confidence intervals (95%CI) using the Website for Statistical Computation [www.vassarstats.net](http://www.vassarstats.net) [22].

Although there are no uniform criteria for the interpretation of sensitivity and specificity values, we considered sensitivity and specificity values  $\geq 0.80$  as high; 0.60–0.79 as moderate and below 0.60 as low. Positive LRs below 2 or negative LRs above 0.5 indicate limited to no diagnostic value [23]. Positive LRs from 2 to 5 or negative LRs between 0.5 and 0.2 were considered small but potentially relevant, because these LRs lead to a small but relevant increase or decrease in the probability of a condition (i.e., cervical radiculopathy). Positive LRs above 5 and negative LRs below 0.2 were considered moderate, because these LRs lead to moderate changes in disease likelihood. Positive LRs above 10 and negative LR below 0.1 were considered high, because these LRs generally lead to large, often decisive increases or decreases of the probability of a condition.[23]

## **Results**

### *Participants*

One hundred and thirty-four patients were included in the study, of whom 66 (49%) were diagnosed with cervical radiculopathy. Fig. 1 provides the flowchart of the study. The mean (SD) age was 49.9 (10.7) years, 49% was female and the median duration of symptoms was 26 (IQR: 13–104) weeks. Patients with cervical radiculopathy more frequently reported arm pain, and a significantly higher arm pain intensity than those without cervical radiculopathy. Patients without radiculopathy more often reported neck pain, and they rated their neck pain intensity significantly higher than patients with cervical radiculopathy. Patients with cervical radiculopathy more often used neuropathic pain medication (e.g., tramadol, morphine, antidepressants and/or anti-epileptics) than patients without cervical radiculopathy. Although not statistically significant, there was a difference in duration of symptoms between the groups. See Table 1 for further details.

Most of the patients with cervical radiculopathy had reference standard results indicative of C6 and/or C7 nerve root involvement, with a few indications of C5 or C8 involvement.

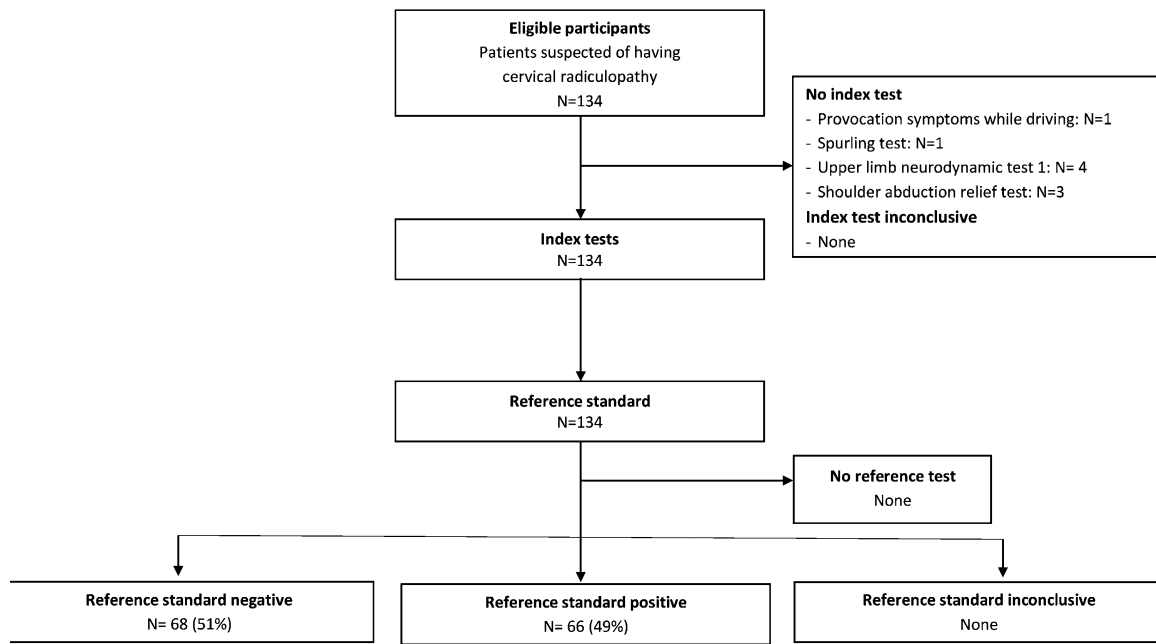


Fig. 1. Flowchart.

Table 1  
Baseline characteristics.

	All participants (N= 134)	Cervical radiculopathy (N= 66)	No cervical radiculopathy (N= 68)	Sig.
Age in years	49.9 (10.7)	49.2 (8.9)	50.5 (12.2)	0.49 <sup>†</sup>
Number of females (%)	65 (48.5)	36 (54.5)	29 (42.6)	0.17 <sup>‡</sup>
Duration of symptoms in weeks* <sup>#</sup>	26 (13–104)	22 (9–92)	44 (13–106)	0.06 <sup>§</sup>
<b>Employment (N (%))</b>				
No employment	28 (21)	9 (14)	19 (28)	0.10 <sup>‡</sup>
Part-time employment	42 (31)	21 (32)	21 (31)	
Full-time employment (≥36 hours/week)	64 (48)	36 (55)	28 (41)	
<b>Patient reported symptoms (N (%))</b>				
Neck pain	114 (85)	48 (73)	66 (97)	<0.001 <sup>‡</sup>
Arm pain	121 (90)	65 (99)	56 (82)	0.002 <sup>‡</sup>
Paraesthesia	95 (71)	55 (83)	40 (59)	0.002 <sup>‡</sup>
Numbness	73 (55)	42 (64)	31 (46)	0.036 <sup>‡</sup>
Paraesthesia and/or numbness	101 (75)	58 (88)	43 (63)	0.001 <sup>‡</sup>
Muscle weakness	78 (58)	41 (62)	37 (54)	0.37 <sup>‡</sup>
Neck pain intensity (NRS: 0–10)*	6 (3)	5 (1–7)	7 (5–8)	0.002 <sup>§</sup>
Arm pain intensity (NRS: 0–10)*	6 (4)	7 (5–7.25)	6 (0.25–7)	0.026 <sup>§</sup>
Disability (NRS: 0–10)*	5.5 (4)	5 (3–7)	6 (4–7)	0.44 <sup>§</sup>
PainDETECT (0–38)	12.0 (5.9)	12.9 (5.4)	11.2 (6.3)	0.11 <sup>†</sup>
Current pain medication use (N (%) yes)	90 (67)	43 (65)	47 (69)	0.63 <sup>‡</sup>
<b>Pain medication type (N (%))</b>				
Paracetamol	60 (45)	23 (35)	37 (54)	0.023 <sup>‡</sup>
NSAIDs	44 (33)	23 (35)	21 (31)	0.63 <sup>‡</sup>
Tramadol	21 (16)	12 (18)	9 (13)	0.43 <sup>‡</sup>
Morphine	9 (7)	7 (11)	2 (3)	0.08 <sup>‡</sup>
Antidepressants	6 (5)	3 (5)	3 (4)	0.97 <sup>‡</sup>
Anti-epileptics	4 (3)	2 (3)	2 (3)	0.98 <sup>‡</sup>
Use of neuropathic pain medication <sup>^</sup>	37 (28)	21 (32)	16 (24)	<0.001 <sup>‡</sup>

Values are presented as mean (SD) for continuous data and as percentages for categorical data unless stated otherwise. \*Data presented as median and interquartile range (IQR). <sup>#</sup>N= 133. NRS = Numeric Rating Scale; NSAIDs = nonsteroidal anti-inflammatory drugs; PainDETECT = Pain Detect Screening questionnaire (max score is 38). <sup>†</sup>Independent Samples T test. <sup>§</sup>Independent Samples Mann Whitney U test. <sup>‡</sup>Pearson Chi square test. <sup>^</sup>Positive if at least one of the following medications was used: tramadol, morphine, antidepressants, anti-epileptics.

Table 2  
Overview of the levels of cervical radiculopathy.

Level	Frequency
C5	2
C6	27
C7	24
C8	1
C5 and C6	1
C6 and C7	10
C7 and C8	1

A more detailed description of the reference standard results is shown in Table 2.

*Missing values*

There were minimal missing data for symptom duration ( $N = 1$ ; 1%) and four index tests, namely: ‘Provocation of symptoms while driving’ ( $N = 1$ ; 1%), because this person did not drive a car, Spurling test ( $N = 1$ ; 1%), ULNT1 ( $N = 4$ ; 3%) and Shoulder abduction relief test ( $N = 3$ ; 2%). There were no missing data for the other interview items and clinical tests.

*Diagnostic accuracy*

*Patient interview items*

For the interview items, the specificity ranged between 0.28 and 0.85, and the sensitivity varied between 0.14 and 0.88 (see Table 3). The interview items ‘arm pain worse than neck pain’, ‘provocation of symptoms when ironing’ and ‘reduction of symptoms by walking with your hand in your pocket’ showed a high specificity (0.81–0.85). The interview items ‘presence of paraesthesia’ (0.83) and ‘presence of paraesthesia and/or numbness’ (0.88) showed a high sensitiv-

ity. Nevertheless, all likelihood ratios were considered small or of limited to no value.

*Clinical examination*

For the clinical examination, the specificity ranged between 0.67 and 0.84, and the sensitivity between 0.28 and 0.67 (see Table 4). The Spurling test (0.84) and the presence of reduced reflexes (0.81) showed a high specificity. None of the clinical tests showed a high sensitivity. Because very few participants experienced hyperaesthesia when assessed with the soft cotton ball ( $N = 6$ ) or the soft brush ( $N = 2$ ), and only one participant experienced amplified reflexes, we decided not to calculate diagnostic accuracy for these outcomes because analyses were underpowered to reach valid conclusions.

No adverse events occurred from performing the clinical tests or the reference standard.

**Discussion**

We found an adequate diagnostic accuracy for the diagnosis of cervical radiculopathy for several patient interview items and clinical tests. When interpreting the diagnostic value of an item, it is important to take the role of the test item in the diagnostic pathway into account. The patient interview is at the start of this pathway, and usually consists of a combination of questions meant to increase or decrease the likelihood of the disease.

In order to confirm the suspicion of cervical radiculopathy, interview items with a high specificity would be most helpful, because of the low chance of a false positive test result. The results of our study indicate that if the arm pain is worse than the neck pain, and/or if the symptoms are provoked when ironing and/or decreased by walking with their

Table 3  
Diagnostic accuracy of the patient-reported interview items ( $N = 134$ ).

Index tests	TP	FP	FN	TN	Sens	95%CI	Spec	95%CI	+LR	95%CI	-LR	95%CI
Arm pain worse than neck pain	38	13	28	55	0.58	0.45–0.70	<b>0.81</b>	0.69–0.89	2.92	1.78–4.80	0.51	0.37–0.70
Arm pain radiates beyond elbow	51	37	15	31	0.77	0.65–0.86	0.46	0.34–0.58	1.38	1.02–1.87	0.48	0.31–0.75
Paraesthesia	55	40	11	28	<b>0.83</b>	0.41–0.58	0.41	0.30–0.54	1.38	1.03–1.84	0.39	0.23–0.66
Numbness	42	31	24	37	0.64	0.51–0.75	0.54	0.42–0.66	1.35	0.97–1.89	0.65	0.47–0.90
Paraesthesia and/or numbness	58	43	8	25	<b>0.88</b>	0.77–0.94	0.37	0.26–0.49	1.35	1.01–1.79	0.32	0.17–0.60
Muscle weakness	41	37	25	31	0.62	0.49–0.74	0.46	0.34–0.58	1.11	0.80–1.51	0.81	0.59–1.11
<b>Provocation of symptoms by:</b>												
Neck extension	40	40	26	28	0.61	0.48–0.72	0.41	0.30–0.54	1.00	0.73–1.26	0.93	0.68–1.27
Neck rotation	31	49	35	19	0.47	0.35–0.60	0.28	0.18–0.40	0.63	0.46–0.88	1.84	1.42–2.40
Ironing	11	13	55	55	0.17	0.09–0.28	<b>0.81</b>	0.69–0.89	0.85	0.48–1.50	1.00	0.81–1.23
Lying in bed	39	37	27	31	0.59	0.46–0.71	0.46	0.34–0.58	1.05	0.77–1.45	0.87	0.64–1.18
Driving a car ( $N = 133$ )	22	29	43	39	0.34	0.23–0.47	0.57	0.45–0.69	0.76	0.51–1.13	1.10	0.87–1.39
<b>Reduction of symptoms by:</b>												
Raising the arm overhead	22	18	44	50	0.33	0.23–0.46	0.74	0.61–0.83	1.22	0.79–1.90	0.88	0.70–1.11
Supporting the arm	18	14	48	54	0.27	0.17–0.40	0.79	0.68–0.88	1.29	0.78–2.11	0.89	0.71–1.11
Resting head by lying down	24	23	42	45	0.36	0.25–0.49	0.66	0.54–0.77	1.04	0.70–1.56	0.93	0.74–1.18
Walking with hand in pocket	9	10	57	58	0.14	0.07–0.25	<b>0.85</b>	0.74–0.92	0.90	0.48–1.70	0.98	0.80–1.20

TP = true positive; FP = false positive; FN = false negative; TN = true negative. Sens = sensitivity; 95%CI: 95% confidence interval; Spec = specificity; +LR = positive likelihood ratio; -LR = negative likelihood ratio. Sensitivity and specificity  $\geq 0.80$  are shown in bold.

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Table 4

Diagnostic accuracy of the clinical tests in patients suspected of having cervical radiculopathy ( $N=134$ ).

Index tests	TP	FP	FN	TN	Sens	95%CI	Spec	95%CI	+LR	95%CI	–LR	95%CI
<b>Provocation/Reduction tests</b>												
Spurling test ( $N=133$ )	38	11	27	57	0.59	0.46–0.70	<b>0.84</b>	0.72–0.91	3.46	2.01–5.94	0.47	0.34–0.65
Upper Limb Neurodynamic test 1 ( $N=130$ )	43	22	21	44	0.67	0.54–0.78	0.67	0.54–0.78	1.95	1.33–2.86	0.48	0.33–0.69
Shoulder abduction relief test ( $N=131$ )	32	17	32	50	0.50	0.37–0.63	0.75	0.62–0.84	1.88	1.22–2.91	0.64	0.48–0.85
Cervical distraction test	29	20	37	48	0.44	0.32–0.57	0.71	0.58–0.81	1.45	0.96–2.18	0.77	0.59–1.00
<b>Clinical neurological examination</b>												
Reduced reflexes*	18	13	47	55	0.28	0.18–0.40	<b>0.81</b>	0.69–0.89	1.38	0.83–2.31	0.85	0.68–1.07
Muscle weakness	20	19	46	49	0.30	0.20–0.43	0.72	0.60–0.82	1.05	0.68–1.64	0.94	0.75–1.18
Sensory changes:												
- Soft cotton ball <sup>#</sup>	28	18	36	46	0.44	0.32–0.57	0.72	0.59–0.82	1.56	1.01–2.39	0.78	0.62–0.98
- Soft brush <sup>‡</sup>	27	19	38	48	0.42	0.30–0.54	0.72	0.59–0.82	1.42	0.93–2.17	0.79	0.61–1.02

TP=true positive; FP=false positive; FN= false negative; TN=true negative. Sens= sensitivity; 95%CI: 95% confidence interval; Spec=specificity; +LR=positive likelihood ratio; –LR=negative likelihood ratio; DOR=diagnostic odds ratio.\*Participants with amplified reflexes ( $N=1$ ) were excluded from this calculation. <sup>#</sup>Participants with hyperaesthesia ( $N=6$ ) were excluded from this calculation. <sup>‡</sup>Participants with hyperaesthesia ( $N=2$ ) were excluded from this calculation. Sensitivity and specificity  $\geq 0.80$  are shown in bold.

hand in their pocket, the likelihood of cervical radiculopathy increases. Subsequently, a positive Spurling test and/or presence of reduced reflexes can be used to further increase the likelihood of cervical radiculopathy.

Test items with a high sensitivity are most useful to make the presence of cervical radiculopathy less likely, because of the low chance of a false negative test result. The results of our study indicate that the likelihood of cervical radiculopathy decreases if the patient does not experience paraesthesia or numbness.

#### Comparison to the literature

The reference standard results indicate that most cervical radiculopathies involved the C6 and/or C7 nerve roots, and to a lesser extend the C5 and C8 nerve roots. This was expected since the C6 and C7 nerve roots are most commonly affected in cervical radiculopathy [1,16]. Therefore, the results of our study mainly apply when these nerve roots are involved.

#### Patients interview

The sensitivity and specificity of the presence of paraesthesia, numbness and weakness differed from those reported in a recent systematic review [13] that based their conclusions on two studies [14,15]. The differences in results might be due to the different reference standard used (i.e., needle electromyography [14,15] versus clinical diagnosis combined with imaging findings), because these reference standards focus on different aspects of the disease (i.e., nerve conduction versus clinical presentation and patho-anatomy).

For the other patient interview items, no comparison to prior research could be made as these have not been previously assessed.

#### Clinical tests

The results for the Spurling test are in line with recent literature in which the Spurling test was reported to be useful to diagnose cervical radiculopathy, based on its high

specificity and moderate to high sensitivity [7,24]. One systematic review found preliminary evidence suggesting that the Spurling test may also be valid to reduce the likelihood of radiculopathy when negative due to the high sensitivity [12]. Comparison of the clinimetric properties of the Spurling's test is complicated because six different operational definitions were used for the Spurling test in the included literature [7,12,25].

The Shoulder abduction relief test showed a moderate specificity and a low sensitivity. One systematic review [7] reported a higher specificity than our findings for the Shoulder abduction relief test (0.85), based on one small study in patients with cervical radiculopathy [26].

The ULNT1 showed a moderate sensitivity and specificity. Three recent systematic reviews concluded that the ULNT1 can be used to reduce the likelihood of cervical radiculopathy, due to the higher sensitivity and moderate specificity [7,12,27]. The sensitivity of the ULNT1 reported in the studies included in the reviews ranged from low to high and the specificity ranged from low to moderate [7,12,27]. The differences between these results can be explained by the variation in reference standards and the different criteria for a positive test between the studies.

The Cervical distraction test showed somewhat lower diagnostic accuracy than the other provocation and reduction tests, indicating that its use to diagnose cervical radiculopathy is limited. One systematic review [7] reported a higher specificity than our findings for the Cervical distraction test (0.97), based on one small study in patients with cervical radiculopathy [26].

#### Clinical neurological examination

The presence of reduced reflexes showed a high specificity and a low sensitivity. The other items showed moderate specificity and low sensitivity. One systematic review concluded that, despite the high sensitivity, the clinical neurological examination is associated with misclassification in cervical radiculopathy, due to its poor specificity [12]. These con-

tradictory results might be explained by the difference in reference standard used (needle electromyography versus clinical presentation combined with medical imaging) and patient population (patients with Grade III neck pain [28] versus patients suspected for cervical radiculopathy).

### *Strengths and limitations*

In the current literature, a variety of reference standards is used to diagnose cervical radiculopathy (e.g., clinical signs and symptoms, medical imaging, and/or needle electromyography) [11]. In our study, the diagnosis cervical radiculopathy was made if clinical signs and symptoms concurred with nerve root compression at a relevant segmental level on MRI [1,4,11]. Given that incongruencies between medical imaging and clinical findings are known to exist rather frequently, this method is preferred over basing a diagnosis on medical imaging or signs and symptoms alone [1,4,11,19,29]. The use of different reference standards makes comparability of the results difficult. Because there is no universal consensus on the gold standard or appropriate reference standard for cervical radiculopathy, the results of all diagnostic accuracy studies for cervical radiculopathy should be interpreted with caution. Moreover, in clinical practice the diagnosis cervical radiculopathy is not solely based on the outcome of one single interview item or clinical test. Clinicians combine patient interview items and clinical tests to verify or falsify their diagnosis. Therefore, future research should determine the diagnostic value of combinations of patient interview items and clinical tests by developing diagnostic models for cervical radiculopathy.

It is noteworthy, that a relatively high number of patients without cervical radiculopathy experienced paraesthesia (59%) or numbness (46%), albeit significantly less than participants with cervical radiculopathy. A comparable number of patients with (62%) and without (54%) radiculopathy reported muscle weakness. These findings can be explained by the fact that participants with neck-arm pain with a suspicion of cervical radiculopathy were included in our study rather than people with a suspicion of non-specific neck pain.

Medication use differed between both groups. Patient without cervical radiculopathy used paracetamol more often than patients with cervical radiculopathy, whereas patients with cervical radiculopathy used neuropathic pain medication more often. The use of more neuropathic pain medication can be explained by the neuropathic pain element in cervical radiculopathy, which is typically more severe and has a higher impact on the quality of life than other types of pain [30]. To what extent medication use influenced the diagnostic accuracy of the patient interview items and clinical tests is difficult to determine. In clinical practice, patients are also often on pain medication while being assessed, and we believe medication use did not compromise the relevance of our findings.

This study was conducted in a multidisciplinary outpatient clinic, in which medical specialist care (e.g., orthopaedics and

neurology) and physiotherapy are combined. This set-up may result in a relatively high number of patients suspected of having cervical radiculopathy attending this clinic. Whether the percentage of patients who effectively had cervical radiculopathy (49%) among those suspected of having cervical radiculopathy was higher than in other primary care settings is uncertain. The prevalence of cervical radiculopathy in our sample was however somewhat lower than most diagnostic accuracy studies performed in a more specialised care setting (i.e., neurology, orthopaedic, spinal surgery or neurosurgery centres), in which the prevalence ranged from 58% to 79% [31–34]. Only one study conducted in four medical facilities showed a lower prevalence (35%) [14]. As we included a sufficiently large number of patients ( $N = 134$ ) suspected of having cervical radiculopathy who were referred for conservative care, we believe our findings are representative and spectrum bias seems unlikely.

Our findings can help clinicians to determine the likelihood of cervical radiculopathy more confidently, potentially reducing the need to refer patients for medical imaging. Making an accurate diagnosis for cervical radiculopathy helps clinicians in determining the best conservative treatment options. There are considerable differences in the conservative management for non-specific neck pain and cervical radiculopathy [16,35] and recommendations in clinical guidelines differ between both groups [4,36].

### **Conclusions**

The patient interview items ‘arm pain worse than neck pain’, ‘provocation of symptoms when ironing’, ‘reduction of symptoms by walking with your hand in your pocket’, the Spurling test and reduced reflexes increase the likelihood of cervical radiculopathy, whereas the absence of paraesthesia and/or numbness decreases the likelihood of cervical radiculopathy.

### **Key Messages**

- This study provides novel insights in the diagnostic value of commonly used patient interview items and clinical tests to diagnose cervical radiculopathy.
- Three interview items and two clinical tests are useful to increase the probability of cervical radiculopathy when positive; and two interview items are useful to decrease the probability of cervical radiculopathy when negative.
- Although most assessed items did not meet our criteria of a sensitivity or specificity value of  $\geq 0.80$ , only a few items had both poor sensitivity and specificity. Although caution is required to not over-interpret diagnostic accuracy values, the relevance of these poor items for cervical radiculopathy should be questioned, if these results are confirmed in future studies.

## Ethical approval

The study was approved by the Medical Ethics Committee of the Elisabeth Amphia Hospital in Tilburg, The Netherlands (METC-2013-02).

## Conflict of interest

The authors declare that they have no conflict of interest.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at <https://doi.org/10.1016/j.physio.2020.07.007>.

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