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Optimising early detection of degenerative cervical myelopathy: a systematic review of quantitative screening tools for primary care

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ABSTRACT

Background Early diagnosis of degenerative cervical myelopathy (DCM) is often challenging due to subtle, non-specific symptoms, limited disease awareness and a lack of definitive diagnostic criteria. As primary care physicians are typically the first to encounter patients with early DCM, equipping them with effective screening tools is crucial for reducing diagnostic delays and improving patient outcomes. This systematic review evaluates the efficacy of quantitative screening methods for DCM that can be implemented in primary care settings.

Methods A systematic search following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was conducted across PubMed, Embase and Cochrane Library up to July 2024 using keywords relevant to DCM screening. Studies were included if they evaluated the sensitivity and specificity of DCM screening tools applicable to primary care settings. Study quality was assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 tool.

Results The search identified 14 studies evaluating 18 screening methods for DCM. Questionnaires consistently showed high diagnostic accuracy, with Youden indices exceeding 0.60, while only three out of nine conventional physical performance tests met the same threshold. Sensor-assisted tests, particularly those using advanced technology like finger-wearable gyro sensors, exhibited the highest diagnostic accuracy but present challenges related to accessibility and learning curves.

Conclusion This review highlights the potential of quantitative screening methods for early DCM detection in primary care. While questionnaires and conventional tests are effective and accessible, sensor-assisted tests offer greater accuracy but face implementation challenges. A tailored, multifaceted approach is crucial for improving outcomes. Future research should focus on validating these tools in diverse populations and standardising diagnostic criteria.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Degenerative cervical myelopathy (DCM) is the leading cause of spinal cord dysfunction worldwide, with diagnostic delays frequently leading to irreversible neurological damage. Although MRI is essential for confirming the diagnosis, the absence of effective screening tools in primary care remains a significant barrier to early detection.

WHAT THIS STUDY ADDS

⇒ This systematic review evaluates the sensitivity, specificity and feasibility of questionnaires, physical performance tests and sensor-assisted methods for early DCM detection in primary care.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study underscores the potential for integrating quantitative screening tools into primary care to improve early DCM detection and timely referrals for MRI, paving the way for refined diagnostic pathways and targeted research to optimise screening practices.

INTRODUCTION

Degenerative cervical myelopathy (DCM) is a progressive condition and the leading cause of spinal cord dysfunction globally.[1 2] It is characterised by the gradual compression of the spinal cord, often due to age-related changes, causing significant neurological impairment and a wide range of symptoms like bilateral arm paresthesia, reduced manual dexterity, gait instability, limb weakness, neck pain, stiffness, Lhermitte's sign and urinary or faecal urgency or incontinence.[3] As a result, early diagnosis is frequently made challenging by the often subtle and non-specific symptoms in the upper and lower extremities of affected patients.[3 4] Additionally, the lack of public and professional awareness, as well as incomplete neurological assessments, also contributes to cases of misdiagnosis or delayed diagnosis.[3 5] Overall, this leads to an average time to diagnosis greater than 2 years, with patients attending more than an average of five physician visits before diagnosis, and greater delays being predictive of increased disability.[6 7] These delays in diagnosis are particularly concerning as they are

associated with incomplete postoperative recovery and impaired quality of life.[8 9]

Although cervical MRI is considered the gold standard for demonstrating spinal cord compression, proper diagnosis of DCM often depends on correlating imaging findings with clinical symptoms and effective assessment on presentation.[6] The diagnostic efficacy of physical exam findings as screening tools for DCM based on measures like sensitivity and specificity has been evaluated.[9 10] However, these findings may be influenced by the subjectivity and examiner dependency associated with physical exam techniques. For example, the Babinski sign was found to have only moderate interobserver reliability.[11] The recent development of other potential screening methods, such as specialised questionaries and physical performance tests, has opened up possibilities for practical and effective DCM screening to take place in the primary care setting.[12–14] Since primary care physicians were found to be the first-line practitioners in 69% of DCM cases, improving the ability of these providers to recognise and diagnose DCM early is crucial.[6]

Our systematic review aims to evaluate the efficacy of various screening methods for DCM that can be effectively implemented in the primary care setting, including questionnaires, conventional physical performance tests and sensor-assisted physical performance tests. The study will focus on key diagnostic metrics such as sensitivity, specificity, Youden index, positive likelihood ratio (LR+) and negative likelihood ratio (LR-). By systematically assessing these measures, this review aims to inform clinical guidelines and advance effective screening tools in primary care, facilitating timely MRI referrals for high-risk patients reducing diagnostic delays that risk irreversible neurological damage.

METHODOLOGY

Literature search

A systematic search was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and included the PubMed, Embase and Cochrane Library databases using refined search terms relevant to DCM screening.[15] The review was not registered in a systematic review database and spanned all previous publications up to July 2024. To ensure the inclusion of unique studies, duplicate records were removed. The search terms included “degenerative cervical myelopathy,” “cervical spondylotic myelopathy,” “cervical myelopathy,” “cervical disc disease,” “myelopathy hand,” “screening,” “screen,” “physical exam,” “clinical assessment,” “dynamic testing,” “dynamics,” “questionnaires,” “videometric” and “gait analysis.” The exact content and logic of the search string queries can be found in online supplemental appendix 1.

Inclusion and exclusion criteria

Studies were included in this review if they focused on adult patients (≥18 years) with suspected or diagnosed DCM and were conducted in primary care settings or involve screening methods applicable to primary care. Only publications obtainable in English were considered. Eligible studies evaluated questionnaires, physical performance assessments or other screening tools for DCM and reported diagnostic accuracy measures such as sensitivity and specificity. Studies were excluded if they focused solely on asymptomatic spinal cord compression or if they did not have relevance to the primary care setting. Additionally, studies that did not evaluate specific screening methods for DCM and did not provide sufficient data on the diagnostic accuracy of the screening methods were excluded from this review.

Study selection and data extraction

Study selection involved a systematic process conducted using professional research software Rayyan (Cambridge, Massachusetts). Two reviewers (SI and PJ) independently screened the titles and abstracts of the remaining articles against the predefined inclusion and exclusion criteria. The full texts of potentially relevant articles were then retrieved and assessed similarly. Data extraction was performed by the same two authors using a standardised form developed and piloted for this review. The following data were extracted from each included study: study characteristics (author, publication year, country, study design and sample size), patient characteristics (age, gender and diagnostic criteria), details of the screening methods evaluated (type of screening test, screening test description and required equipment) and diagnostic accuracy measures (sensitivity and specificity). The Youden index, calculated as the sum of sensitivity and specificity minus one, was used to assess the balance between sensitivity and specificity, with a value of 0.60 or greater indicating an effective diagnostic method.[16] Also, LR+ and LR- were derived from the sensitivity and specificity data. Lastly, included study quality was evaluated using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS)-2 tool.[17] Any discrepancies found during the extraction and review process were resolved through discussion with the senior author (SJ).

RESULTS

A total of 785 citations were retrieved from three different databases. After removing duplicates and conducting a thorough screening process, 14 studies met the inclusion criteria and were included in the analysis (figure 1). These studies, published between 2010 and 2024, were conducted in the USA, China or Japan (table 1). All studies employed a case-control design, with all but two being prospective. The sample sizes varied widely, ranging from 39 to 1702 subjects, totalling 6478 subjects. Reported diagnostic criteria for DCM varied across studies. While some studies explicitly mentioned MRI to confirm spinal cord compression, others referred more broadly to the use of advanced imaging or evaluation by spinal surgeons without providing further details. This lack of consistency

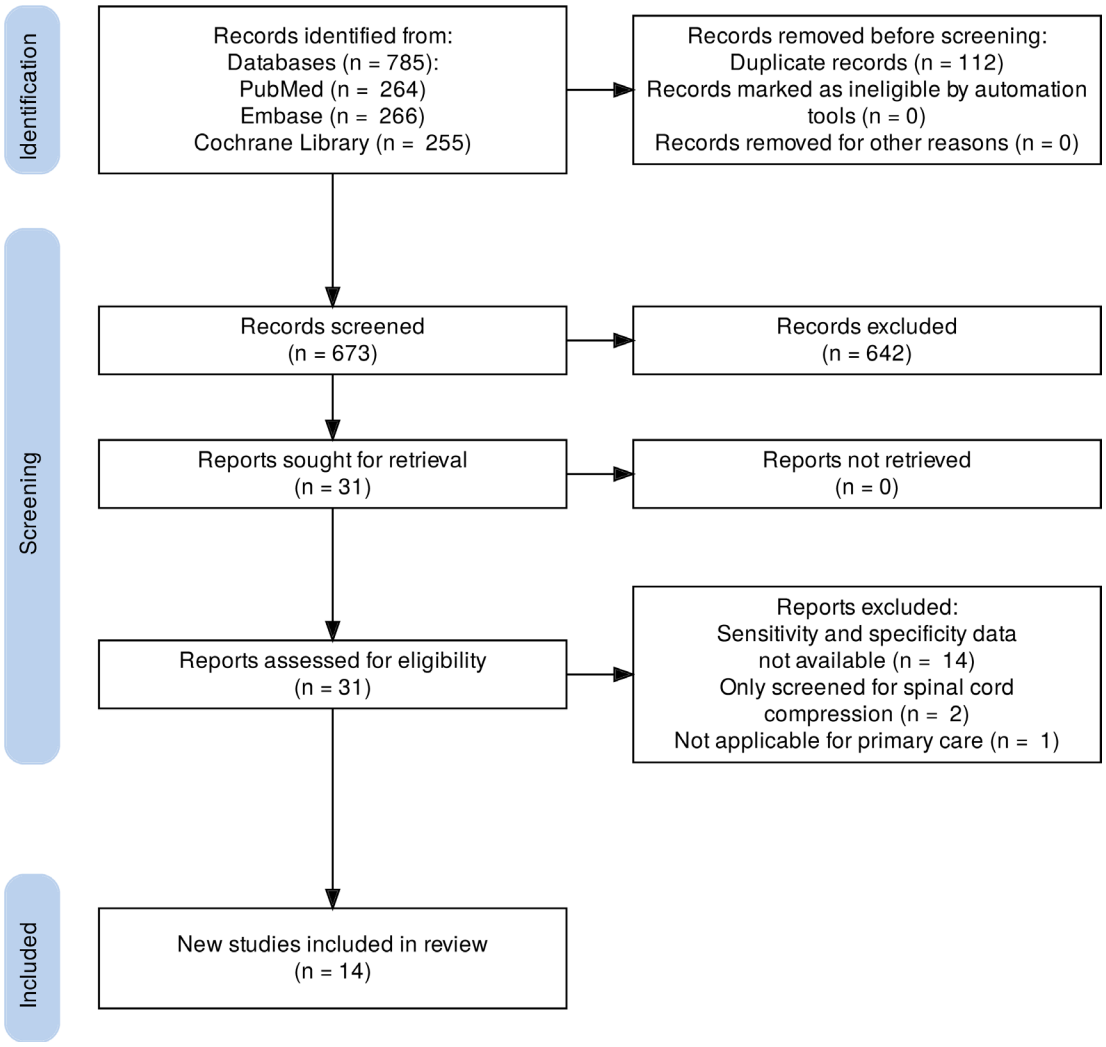

Figure 1 PRISMA Flow Diagram for Study Selection.

in reporting may reflect variability in diagnostic practices or incomplete descriptions within the studies. 13 studies used control patients without any neurological symptoms or history of DCM. One study[13] used patients diagnosed with peripheral nerve compression syndromes, such as carpal tunnel syndrome, and other neuropathies as controls for comparison with the DCM group.[12] An assessment using the QUADAS-2 tool indicated a potential risk of bias in patient selection, primarily due to the case-control nature of the studies (table 2). However, applicability concerns and other measures of bias were generally low. The screening methods evaluated were categorised into three groups: questionnaires, conventional physical performance tests and sensor-assisted physical performance tests.

Questionnaires

Two studies evaluated the effectiveness of questionnaires in DCM screening (table 3). The DOWN questionnaire is a four-item self-administered survey that asks about feelings of off-balance when standing and symptoms of clumsiness, weakness and numbness in the arms or hands. It was studied by Barkoh *et al* in 92 patients with a cut-off of four positive responses and was found to have a sensitivity of 71.74% and a specificity of 89.13%.[12] In contrast, Kobayashi *et al* examined an eight-item self-administered questionnaire derived from the Japanese Orthopedic Association Cervical Myelopathy Evaluation Questionnaire (JAOCMEQ) in 111 patients. Scored on a scale from 0 to 13, this questionnaire used a cut-off score of ≥6 and demonstrated a sensitivity of 93.5% and a specificity of 67.3%.[13] The Youden index for these questionnaires was nearly the same, ranging from 0.608 (JAOCMEQ-derived questionnaire) to 0.609 (DOWN questionnaire), with both questionnaires achieving a Youden index of 0.60 or greater.

Conventional physical performance testing

Five studies evaluated the effectiveness of conventional physical performance tests in screening for DCM (table 4). These methods, which assessed balance, gait, hand motor function and dexterity without sensors, showed varying diagnostic performance. Sensitivity ranged from 53.0% (NIH Toolbox Motor Battery (NIHTBm)—nine-hole peg test) to 93.3% (grip strength test).[18 19] Specificity ranged from 58.8% (10 s grip and release test (GRT))

Table 1 Study characteristics and screening test groups for DCM

Study	Country	Study design	Sample size	Sex (% male)	Mean age	Reported DCM diagnosis reference standard	Screening test group
Barkoh[11]	The USA	Case-control/ prospective	Total: 92 DCM: 46 Ctrl: 46	DCM: 70% Ctrl: 59%	DCM: 66 Ctrl: 53	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Questionnaire
Kobayashi[12]	Japan	Case-control/ prospective	Total: 111 DCM: 62 Ctrl: 49	DCM: 77% Ctrl: 39%	DCM: 62 Ctrl: 62	Evaluation by spine surgeons	Questionnaire
Muhammad[32]	USA	Case-control/ retrospective	Total: 82 DCM: 17 Ctrl: 37	DCM: 44% Ctrl: 19%	DCM: 57 Ctrl: 53	Evaluation by at least one attending neurosurgeon	Conventional physical performance
Ye[37]	China	Case-control/ retrospective	Total: 1702 DCM: 508 Ctrl: 1194	DCM: 60% Ctrl: 44%	DCM: 56 Ctrl: 40	Evaluation by spine surgeons	Conventional physical performance
Kobayashi[20]	Japan	Case-control/ prospective	Total: 968 DCM: 247 Ctrl: 721	DCM: 67% Ctrl: 38%	DCM: 65 Ctrl: 66	Evaluation by spine surgeons	Conventional physical performance
Kobayashi[18]	Japan	Case-control/ prospective	Total: 984 DCM: 249 Ctrl: 735	DCM: 66% Ctrl: 38%	DCM: 65 Ctrl: 66	Evaluation by spine surgeons	Conventional physical performance
Machino[19]	Japan	Case-control/ prospective	Total: 1272 DCM: 454 Ctrl: 818	DCM: 67% Ctrl: 50%	DCM: 65 Ctrl: 60	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Conventional physical performance
Koyama[38]	Japan	Case-control/ prospective	Total: 61 DCM: 24 Ctrl: 37	DCM: 58% Ctrl: 41%	DCM: 61 Ctrl: 55	Evaluation by spine surgeons	Sensor-assisted physical performance
Makino[21]	Japan	Case-control/ prospective	Total: 69 DCM: 44 Ctrl: 25	DCM: 73% Ctrl: 76%	DCM: 65 Ctrl: 66	Evaluation using advanced imaging and clinical exam findings	Sensor-assisted physical performance
Li[23]	China	Case-control/ prospective	Total: 555 DCM: 258 Ctrl: 297	DCM: 54% Ctrl: 55%	DCM: 55 Ctrl: 49	Evaluation by spine surgeons	Sensor-assisted physical performance
Yamada[39]	Japan	Case-control/ prospective	Total: 104 DCM: 38 Ctrl: 66	DCM: 61% Ctrl: 42%	DCM: 66 Ctrl: 69	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Sensor-assisted physical performance
Ibara[14]	Japan	Case-control/ prospective	Total: 39 DCM: 22 Ctrl: 17	DCM: 50% Ctrl: 47%	DCM: 69 Ctrl: 63	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Sensor-assisted physical performance
Koyama[22]	Japan	Case-control/ prospective	Total: 87 DCM: 31 Ctrl: 29	DCM: 52% Ctrl: 41%	DCM: 67 Ctrl: 64	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Sensor-assisted physical performance
Koyama[24]	Japan	Case-control/ prospective	Total: 78 DCM: 50 Ctrl: 28	DCM: 64% Ctrl: 43%	DCM: 65 Ctrl: 65	Evaluation by spine surgeons based on advanced imaging and clinical exam findings	Sensor-assisted physical performance

Ctrl, control; DCM, degenerative cervical myelopathy.

Table 2 Assessment of risk of bias and applicability concerns using the Quality Assessment of Diagnostic Accuracy Studies-2 tool

Study	Risk of bias				Applicability concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Barkoh[11]	High	High	Low	Low	Low	Low	Low
Kobayashi[12]	High	Low	Unclear	Low	Low	Low	Low
Muhammad[32]	High	Unclear	Low	Low	Low	Low	Low
Ye[37]	High	Low	Low	Low	Low	Low	Low
Kobayashi[20]	High	Low	Low	Unclear	Low	Low	Low
Kobayashi[18]	High	High	Low	Low	Low	Low	Low
Machino[19]	Low	Low	Low	Low	Low	Low	Low
Koyama[38]	High	Low	Low	Low	Low	Low	Low
Makino[21]	High	Low	Low	Low	Low	Low	Low
Li[23]	Low	Low	Low	Low	Low	Low	Low
Yamada[39]	High	Low	Low	Low	Low	Low	Low
Ibara[14]	High	Low	Low	Low	Low	Low	Low
Koyama[22]	High	Low	Low	Low	Low	Low	Low
Koyama[24]	High	Low	Low	Low	Low	Low	Low

to 91.0% (NIHTBm—walking gait test).[19 20] The Youden index ranged from 0.361 to 0.663, with the highest value achieved by a combination of the 10 s GRT and grip strength test.[20] Notably, Machino *et al* directly compared the diagnostic performance of the 10 s GRT and the 10 s step test in the same population.[19] Only three out of the nine conventional physical performance tests demonstrated a Youden index of 0.60 or greater.

Sensor-assisted physical performance testing

Seven studies evaluated advanced screening tests for DCM using specialised sensors and instruments to capture and precisely quantify movement parameters during physical performance tests such as the 10 s GRT and the timed Up and Go test (table 5). Sensitivity for these tests ranged from 74.2% (finger motion sensor during the 10 s GRT) to 91.0% (gait analyser).[21 22] Specificity varied from 60.7% (finger motion sensor during the 10 s GRT) to 95.0% (finger-wearable gyro sensor during the 10 s GRT).[23 24] The Youden index for these sensor-assisted tests ranged from 0.520 to 0.841, with the highest value achieved by the finger-wearable gyro sensor during the 10 s GRT.[23] Notably, five out of the seven sensor-assisted screening methods demonstrated a Youden index of 0.60 or greater.

DISCUSSION

For screening methods to be effective, they must address an important health problem, have available treatment options, be reliable and acceptable to the population, be cost-effective and exhibit high sensitivity and specificity.[25] While MRI plays a crucial role in diagnosing DCM, assessing functional deficits caused by spinal cord compression

Table 3 Diagnostic accuracy of questionnaires for degenerative cervical myelopathy screening

Study	Screening test description	Sensitivity (%)	Specificity (%)	Youden index	LR+	LR-	Required equipment
Barkoh[12]	Self-administered DOWN questionnaire with four questions about feeling off-balance when standing and feeling clumsiness, weakness and numbness in the arms or hands	71.74	89.13	0.609	6.60	0.32	Questionnaire
Kobayashi[13]	Self-administered questionnaire with eight questions derived from the Japanese Orthopedic Association Cervical Myelopathy Evaluation Questionnaire	93.5	67.3	0.608	2.86	0.10	Questionnaire

LR-, negative likelihood ratio; LR+, positive likelihood ratio.

Table 4 Diagnostic accuracy of conventional physical performance testing for degenerative cervical myelopathy

Study	Screening test description	Sensitivity (%)	Specificity (%)	Youden index	LR+	LR-	Required equipment
Muhammad[32]	NIHTBm—nine-hole peg test	53.0	89.0	0.420	4.82	0.53	Nine-hole peg test kit
	NIHTBm—grip strength test	76.5	77.3	0.538	3.37	0.30	Grip dynamometer
	NIHTBm—standing balance test	50.0	86.0	0.360	3.57	0.58	N/A
	NIHTBm—walking gait test	64.7	91.0	0.557	7.19	0.39	N/A
Ye[37]	6 s GRT	72.4	74.1	0.464	2.79	0.37	Timer
Kobayashi[20]	Combination of 10 s GRT and grip strength test	88.2	78.1	0.663	4.03	0.15	Timer and grip dynamometer
Kobayashi[18]	Grip strength test	93.3	71.6	0.649	3.29	0.09	Grip dynamometer
Machino[19]	10 s GRT	77.3	58.8	0.361	1.88	0.38	Timer
	10 s step test	92.3	67.8	0.601	2.87	0.11	Timer

GRT, grip and release test; LR-, negative likelihood ratio; LR+, positive likelihood ratio; N/A, not applicable; NIHTBm, NIH Toolbox Motor Battery.

relies more on clinical evaluation and patient history than on imaging alone.[26 27] Several past reviews have evaluated the diagnostic sensitivity and specificity of clinical signs and reflexes such as the Hoffmann sign, Babinski reflex and clonus.[9 10] However, the screening utility of these signs remains debatable due to many demonstrating low sensitivity and specificity results.[9 10] In a recent meta-analysis by Jiang *et al*, which calculated pooled sensitivity and specificity values for pathological reflexes, it was revealed that only the Trömner sign had an acceptable screening profile with a sensitivity of 94%, a specificity of 93% and a Youden index of 0.87.[9 28 29] However, the analysis included only 126 patients across two studies, limiting the generalisability of this finding. In contrast, the almost identical Hoffmann sign was found to have a sensitivity of 58%, a specificity of 72% and a Youden index of 0.30, based on a sample of 898 patients across eight studies. Notably, all other pathological reflexes suffered from poor DCM sensitivity.[9] Moreover, the uncertain inter-rater reliability of these clinical signs, such as the Babinski sign, further burdens their diagnostic use.[11] This is especially relevant for primary care physicians who may not have significant

Table 5 Diagnostic accuracy of sensor-assisted physical performance testing for degenerative cervical myelopathy screening

Study	Screening test description	Sensitivity (%)	Specificity (%)	Youden index	LR+	LR-	Required Equipment
Koyama [38]	Timed Up and Go test with a laser range sensor	89.2	79.2	0.684	4.29	0.14	Pressure and laser range sensor
Makino [21]	Used a long thin-type sensor sheet to analyse gait	91.0	77.0	0.680	3.96	0.12	Long thin-type sensor sheet
Li [23]	Uses a finger-wearable gyro sensor to capture movement parameters during the 10 s GRT	89.1	95.0	0.841	17.82	0.11	Finger-wearable Bluetooth gyro sensor
Yamada [39]	Used a tablet device to record writing behavioural parameters to during a drawing task	76.0	76.0	0.520	3.17	0.32	Tablet and stylus pen
Ibara [14]	10 s GRT with movement parameters captured using a smartphone application	90.9	88.2	0.791	7.70	0.10	Smartphone
Koyama [22]	Used a finger motion sensor to capture movement parameters during the 10 s GRT	74.2	89.7	0.639	7.21	0.29	Noncontact sensor able to track hand and finger movements
Koyama [24]	Used a finger motion sensor to capture movement parameters during the 10 s GRT	84.0	60.7	0.447	2.14	0.26	Noncontact sensor able to track hand and finger movements

GRT, grip and release test; LR-, negative likelihood ratio; LR+, positive likelihood ratio.

expertise in eliciting and interpreting these clinical signs, even though they are often the first to encounter and identify the majority of DCM cases.[3 5 6]

The DOWN and JAOCMEQ-derived questionnaire screening tools showed significant diagnostic accuracy, with similar Youden indices.[12 13] The DOWN questionnaire, using four positive responses as the cut-off, reported a greater specificity than the JAOCMEQ-derived questionnaire. Notably the JAOCMEQ-derived questionnaire lacks specific questions on gait imbalance and hand dysfunction, predominant DCM symptoms that are directly addressed in the DOWN questionnaire, possibly explaining the latter's higher specificity. Additionally, the JAOCMEQ-derived questionnaire may assign points for musculoskeletal complaints related to hip or knee pathology, concurrent prostate or lumbar issues, and cervical radiculopathy. As a result, a positive screen with the JAOCMEQ-derived questionnaire may lead to further history taking that is not specific for myelopathy. Overall, their ease of use and lack of need for specialised equipment make them particularly suitable for initial DCM screening in primary care settings.

Although functional performance impairment is a crucial component of DCM diagnosis, the diagnostic efficacy of conventional physical performance tests has been less explored.[4] Performance in daily activities, particularly those involving fine hand manipulation and walking coordination, is thought to reflect the deficits caused by cervical spinal cord compression in DCM, which primarily impacts the dorsal column and corticospinal tract.[27 30] Law *et al* recently reviewed the use of quantitative physical performance tests in DCM screening, but their analysis was limited to raw performance metrics.[27] Our study extended this by examining specific diagnostic accuracy measures such as sensitivity and specificity. For instance, the combination of the 10 s GRT and grip strength test from Kobayashi *et al* achieved sensitivity and specificity scores of 88.2% and 78.1%, respectively.[20] These tests require only a dynamometer and a timer, making them easily accessible. Additionally, the evaluation of grip strength alone by Kobayashi *et al* showed favourable sensitivity and specificity values of 93.3% and 71.6%, respectively.[18]

The recent proliferation of sensor-assisted physical performance tests has yielded impressive screening values, particularly with the finger-wearable Bluetooth gyro sensor model outlined by Li *et al*.[23] By averaging the top 10 linear acceleration movement parameters while wearing the gyro sensor on the little finger during the 10 s GRT, they achieved a sensitivity of 89.1% and a specificity of 95.0%. However, the need for specialised equipment poses a barrier to widespread adoption. Interestingly, Ibara *et al* described a method using a smartphone and a mobile application to measure thumb interphalangeal joint movement parameters during the 10 s GRT, demonstrating high screening metrics with a sensitivity of 90.9% and a specificity of 88.2%.[14] This standardised method requires no specialised hardware, making it accessible for primary care providers and patients seeking self-administration.

Current guidelines suggest screening for DCM in patients presenting with symptoms of myelopathy, followed by MRI to confirm spinal cord compression.[31] Surgery is often indicated for moderate-to-severe cases to prevent irreversible neurological damage, while mild cases may initially be managed conservatively, with surgery considered if symptoms do not improve or worsen.[32] However, significant diagnostic delays remain a challenge in primary care settings, which overwhelmingly serve as the first point of contact for DCM cases. The over 2-year diagnostic delay reported by Behrbalk *et al* highlights critical gaps in the primary care management of DCM, including low clinical suspicion, inadequate neurological examinations and reliance on nonspecific treatments.[6] Family physicians often delayed referring patients for cervical MRI, instead relying on less sensitive tools like CT scans, further postponing definitive diagnosis.[6] Previous studies emphasise the importance of timely cervical MRI for patients with persistent neck or arm pain, worsening symptoms or neurological deficits, yet referrals were predominantly made by neurologists or neurosurgeons later in the diagnostic pathway.[6 33]

The screening methods summarised in this study aim to address these gaps by enabling primary care physicians to identify high-risk DCM patients earlier and more efficiently. Importantly, these tools are not intended to replace clinical evaluation but to complement it, ensuring efficient resource utilisation while improving the early detection of DCM. They are particularly valuable in patients presenting with myelopathic symptoms such as limb clumsiness, unsteady gait or non-specific complaints like neck pain, which are often misdiagnosed as carpal tunnel syndrome or radiculopathy.[6] While not designed to definitively differentiate DCM from peripheral nerve disorders, these tools can flag features suggestive of spinal cord involvement, such as bilateral symptoms or gait abnormalities, prompting timely cervical MRI. Additionally, with a DCM prevalence of 2.3% in the adult population, generalised screening initiatives could be considered for high-risk populations, such as individuals over the age of 50, as most DCM diagnoses occur in their 50s while the condition is uncommon in younger adults.[4 34 35] Those with cervical stenosis are also particularly at risk, with evidence indicating that asymptomatic cervical cord compression, present in approximately one in four people, carries a 3% annual risk of developing myelopathy.[34 36] Such initiatives might involve one-time screening or evaluations at intervals of 3–5 years. However, further research is needed to validate these approaches, identify specific target populations and determine optimal screening intervals.

Based on our findings, we propose a multifaceted screening approach in primary care to guide appropriate referral to a spine specialist and inform MRI decisions. The high sensitivity and specificity of the DOWN and JAOCMEQ-derived questionnaires make them ideal for initial screening due to their ease of use and the absence

of specialised equipment.[12 13] For those who screen positive, conventional physical performance tests, such as the 10 s GRT combined with grip strength measurement, provide additional diagnostic insights with minimal equipment and training.[20] Furthermore, the smartphone-assisted method described by Ibara *et al* offers a viable alternative.[14] In spine clinics or practices serving high-risk DCM populations, advanced sensor-assisted physical performance tests, like finger-wearable gyro sensors and gait analysers, can offer highly accurate screening options.[21 23] Implementing this tiered screening strategy allows primary care providers to identify DCM early, ensuring timely referral and intervention, and ultimately improving patient outcomes.[8 9]

While this is the first review to summarise the sensitivity and specificity of quantitative DCM screening tests useful in primary care, there are limitations that should be considered. The use of the QUADAS-2 tool revealed potential biases, particularly in patient selection, due to the predominance of case-control study designs. This could have led to inflated diagnostic accuracy measures. The variability in reported diagnostic criteria, with some studies providing limited details about imaging modalities or clinical evaluation methods, further complicates comparisons across studies and limits generalisability. While two studies were classified as retrospective, both were secondary analyses of prospectively collected data, providing valuable insights consistent with the methodologies of the included prospective studies. Additionally, the reliance on specialised equipment for sensor-assisted tests may limit their practical application in primary care, especially in resource-limited settings. Lastly, Machino *et al* was the only study to compare different screening methods, such as the 10 s GRT and the 10 s step test, within the same population.[19] However, the lack of such direct comparisons across other studies makes it difficult to establish the most effective approach for DCM screening. Future research should aim to address these limitations by adopting a prospective cohort design, standardising diagnostic criteria and comparing the efficacy of various screening tools across diverse settings.

CONCLUSION

This systematic review highlights the potential of various quantitative screening methods for the early detection of DCM in primary care settings. The findings suggest that while questionnaires and conventional physical performance tests offer accessible and effective initial screening options, sensor-assisted tests may provide higher diagnostic accuracy, although with limitations related to equipment accessibility and learning curve. This emphasises the importance of a multifaceted screening approach, tailored to the resources and expertise available in the primary care environment. Moving forward, more rigorous, prospective research is needed to validate these screening methods across diverse populations and settings, with an emphasis on standardising diagnostic criteria and directly comparing the efficacy of different tools. Early and accurate screening for DCM remains crucial to improving patient outcomes, and the insights from this review provide a foundation for refining and implementing screening strategies in clinical practice.

Contributors SI: conceptualisation of the work, literature review, study selection, data extraction and interpretation, writing and critical revision of the manuscript, and approval of the final version. PJ: literature review, study selection, data extraction and approval of the final version. SJ: supervision and conceptualisation of the work, data interpretation, critical revision of the manuscript, approval of the final version and guarantor.

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