Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Exercise-Based Rehabilitation in Degenerative Cervical Myelopathy and Cervical Spinal Stenosis: A Systematic Review

Chenxi Dong

cdong@eduhk.hk

The Education University of Hong Kong https://orcid.org/0009-0007-6656-5353

Systematic Review

Keywords: degenerative cervical myelopathy, cervical spinal stenosis, exercise therapy, rehabilitation, physical therapy, postoperative care, systematic review

Posted Date: August 7th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10614961/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: The authors declare no competing interests.

Abstract

Background

Degenerative cervical myelopathy (DCM) is the primary cause of non-traumatic spinal cord impairment in adults. Exercise-based rehabilitation is widely used perioperatively, but its disease-specific efficacy and mechanisms remain unproven.

Objective

To characterize exercise interventions studied in adults with imaging-confirmed degenerative cervical spinal stenosis (CSS) or DCM, evaluate their neurological and functional effects, and distinguish clinically supported mechanisms from biological hypotheses.

Methods

We searched PubMed, Scopus, and Google Scholar (January 2006–August 2026) for studies of exercise interventions in adults with imaging-confirmed degenerative CSS or DCM, excluding non-degenerative pathologies. Given heterogeneity across interventions and populations, findings were synthesized narratively, and the certainty of the evidence was rated using the GRADE framework.

Results

Of 3,192 identified records, 88 met the inclusion criteria. Exercise improved balance, mobility, independence, and pain, with the largest and most consistent gains from multimodal, task-specific programs after surgical decompression. Most controlled studies were small or non-randomized, and postoperative trials showed variable benefit relative to usual care. Evidence for isolated neck strengthening, deep cervical flexor training, postural correction, and aerobic conditioning was indirect or mechanistic. No study demonstrated structural reversal of stenosis or canal expansion.

Conclusions

Exercise-based rehabilitation improves balance, mobility, independence, and pain in stable mild DCM and after surgical decompression, with the strongest and most consistent gains from multimodal, task-specific programs. It does not reverse stenosis or enlarge the canal, and it must not delay surgical assessment in progressive or severe disease.

1. Introduction

Degenerative cervical myelopathy (DCM) is symptomatic spinal cord dysfunction caused by age-related narrowing of the cervical canal. Causes include disc degeneration, osteophytes, ligamentum flavum hypertrophy, ossification of the posterior longitudinal ligament, and spondylolisthesis (Fehlings et al., 2013a; Nouri et al., 2015; Tu et al., 2021). Patients present with impaired hand dexterity, gait imbalance, weakness, numbness, hyperreflexia, spasticity, and sphincter disturbance. Diagnosis is often delayed (Cervellini et al., 2025; Davies et al., 2022).

Compression alone does not explain DCM; repeated flexion and extension strain the cord. Chronic compression causes ischemia, disruption of the blood–spinal cord barrier, neuroinflammation, demyelination, and axonal injury (Karadimas et al., 2013; Kalsi-Ryan et al., 2013; Thompson et al., 2024). These mechanisms justify rehabilitation targeting strength, balance, motor learning, and compensation. They do not imply that exercise reverses osteophytes, ossification, or fixed stenosis.

Management depends on severity. Guidelines recommend surgery for moderate and severe DCM (Fehlings et al., 2013b). Mild DCM may be managed with surgery or with a supervised trial of structured rehabilitation (Fehlings et al., 2017). Postoperative rehabilitation may improve activity and participation, but its content, dose, and timing remain uncertain (Badran et al., 2018; Boerger et al., 2022; Montpetit et al., 2026; Sakaguchi et al., 2024).

In this study, we asked three research questions:

- **RQ1 (effectiveness).** In adults with CSS or DCM, does exercise-based rehabilitation improve neurological status and physical function?
- **RQ2 (modalities).** Which exercise modalities have been studied, and which have direct evidence in DCM?
- **RQ3 (mechanisms and role).** Which mechanisms of benefit are supported by evidence, and what role should exercise play in DCM management?

2. Methods

We followed PRISMA 2020 (Page et al., 2021). We included adults aged 18 years or older with imaging-confirmed degenerative CSS or DCM who received an exercise-based intervention and reported clinical outcomes. Eligible interventions included neck strengthening, deep cervical flexor training, stabilization, balance or proprioceptive training, aerobic conditioning, functional task practice, and technology-assisted exercise. Eligible outcomes included the modified Japanese Orthopaedic Association (mJOA) score, Nurick grade, Neck Disability Index (NDI), pain, balance, gait, upper-limb function, independence, quality of life, and adverse events. We excluded traumatic spinal cord injury and inflammatory, infectious, congenital, or neoplastic disorders, and we excluded case reports and very small case series from the main synthesis.

We searched PubMed, Scopus, and Google Scholar from 1 January 2006 through 5 August 2026. The PubMed strategy combined terms for cervical stenosis or myelopathy with exercise and rehabilitation

terms: ("cervical spinal stenosis" OR "degenerative cervical myelopathy" OR "cervical spondylotic myelopathy" OR "cervical myelopathy") AND (exercise OR physiotherapy OR "physical therapy" OR rehabilitation OR strengthening OR stabilization OR proprioception OR balance OR aerobic OR "neck exercise"). Syntax was adapted for each database.

We identified 3,192 records and removed 1,023 duplicates. We screened 2,169 records by title and abstract. Of 385 full-text reports assessed, 297 were excluded, and 88 were included (Fig. 1).

The bibliometric landscape of the included studies is summarized in Fig. 2. Publications increased after 2015, with 32 reports published in 2016–2020 and 33 in 2021–2026. The United States contributed the largest share of the included studies (24, 27.3%), followed by Japan (18, 20.5%), China (14, 15.9%), and Canada (10, 11.4%). These trends parallel broader bibliometric analyses of cervical spondylosis and DCM research (Jiang et al., 2025).

The randomized controlled trials (RCTs) comprised 27.3% (n = 24) of the 88 included studies, cohort studies 35.2% (n = 31), case-control studies 9.1% (n = 8), systematic reviews 20.5% (n = 18), and narrative reviews 8.0% (n = 7).

Spine published the most included studies (12, 13.6%), followed by Global Spine Journal (10, 11.4%), European Spine Journal (8, 9.1%), Journal of Neurosurgery: Spine (7, 8.0%), Clinical Rehabilitation (5, 5.7%), Spinal Cord (4, 4.5%), BMC Musculoskeletal Disorders (3, 3.4%), Frontiers in Bioengineering and Biotechnology (3, 3.4%), Journal of Clinical Medicine (3, 3.4%), and World Neurosurgery (3, 3.4%). The remaining 30 studies (34.1%) were distributed across 28 other journals, reflecting the cross-specialty nature of DCM rehabilitation research.

These bibliometric patterns describe research activity, not certainty or treatment effectiveness.

3. Exercise Modalities and Clinical Effectiveness (RQ1 & RQ2)

To address RQ1 (effectiveness) and RQ2 (modalities), we synthesized outcomes across nine different exercise categories (see Fig. 3). For RQ1, exercise-based rehabilitation enhances physical functions in DCM, including balance, mobility, independence, and pain, with the most significant and consistent improvements seen in multimodal, task-specific programs following surgical decompression. The neurological status, assessed by the mJOA, showed small improvements in observational studies of mild-DCM and postoperative groups; however, no study reported structural reversal of stenosis or canal expansion. Regarding RQ2, out of the nine identified modalities, proprioceptive and balance training, multimodal rehabilitation, and technology-assisted methods have direct evidence for DCM. In contrast, isometric strengthening, deep cervical flexor exercises, stabilization, aerobic conditioning, flexion exercises, and postural correction are supported by indirect evidence from cervical spondylosis, neck pain, or biomechanical reasoning.

3.1 Isometric Neck Exercises

Isometric exercises activate the cervical muscles without joint movement. They are the most studied standalone modality in this review and carry the strongest evidence for an isolated intervention (NDI −12.4 points; Sadeghi et al., 2022). They appear safe, with no serious adverse events in trials, and are suitable for patients with significant stenosis (Blanpied et al., 2017).

Intervention Protocol. Perform six directions: flexion, extension, bilateral lateral flexion, and bilateral rotation. Press the head against a resisting hand. Hold each contraction for 10 seconds, 5 repetitions per direction, 3 sets daily, 6 days per week, for 4–8 weeks, with 5-second rests (Sadeghi et al., 2022).

Evidence. In an RCT of cervical spondylosis, NDI fell by 12.4 points (minimal clinically important difference, 7.5; $p < 0.001$), and visual analogue scale (VAS) pain fell by 3.8 points (Sadeghi et al., 2022). Observational data suggest that mJOA increases by 1–2 points in mild DCM. A 6-week isometric program also improved function and pain in patients with cervical spondylotic myelopathy (CSM) (Sundaramurthy et al., 2012). Active neck training is supported by the wider neck-exercise literature (Ylinen et al., 2003; Gross et al., 2016). Certainty of evidence (GRADE): Low: one RCT in cervical spondylosis (indirect), observational DCM data, and consistent neck-exercise literature.

3.2 Deep Cervical Flexor (DCF) Training

DCF training targets the longus colli and longus capitis, the primary anterior stabilizers that maintain cervical lordosis, and reduces joint position error (JPE) by 2.1° while improving forward-head posture.

Intervention Protocol. Craniocervical flexion (CCF) protocol (Jull et al., 2008): supine, with a pressure biofeedback unit (Stabilizer, Chattanooga Group) beneath the suboccipital region, perform a slow, controlled nodding motion ("chin tuck" without superficial flexor activation) to 22 mmHg, progressing through 24, 26, 28, and 30 mmHg. Hold each pressure level for 10 seconds, 10 repetitions, twice daily, for 6–8 weeks; progress only when the target pressure is maintained without compensatory activation of the sternocleidomastoid or anterior scalene.

Evidence. JPE decreased 2.1° from baseline (Rahnama et al., 2023). CCF training outperformed proprioception training on the craniocervical flexion test (Gallego Izquierdo et al., 2016). In DCM populations, NDI reductions of 8–15 points have been reported; patients with forward-head posture showed a 3–7° increase in the craniovertebral angle (Kang et al., 2021). Certainty of evidence (GRADE): Low: consistent effects, but mostly non-DCM populations.

3.3 Cervical Stabilization Exercises

Cervical stabilization exercises combine scapular and cervical muscle co-activation to restore global spinal stability, improving craniovertebral angle and post-surgical outcomes.

Intervention Protocol. Progress through supine (weeks 1–2), sitting (weeks 3–4), and standing (weeks 5–8). Each session pairs scapular stabilization (scapular retraction, wall slides, prone horizontal abduction) with cervical isometric co-contraction, 3 times weekly for 6–8 weeks (30–45 minutes per

session). Adding thoracic extension improves the craniovertebral angle more than cervical exercise alone (Kang et al., 2021).

Evidence. Perturbation-based balance training with cervical stabilization reduced postural sway and improved dynamic balance in postoperative DCM patients over a 4-week period (Cheng et al., 2020). Combined programs report NDI gains of 10–18 points. Early stabilizer training after anterior cervical discectomy and fusion was as effective as usual care (McFarland et al., 2020). Certainty of evidence (GRADE): Low: limited DCM-specific studies; most evidence from neck pain populations.

3.4 Proprioceptive and Balance Training

Proprioceptive and balance training targets the cervical sensorimotor deficits that drive balance impairment and fall risk in DCM, improving balance and gait even in the absence of structural neurological recovery.

Intervention Protocol. (a) Joint position sense retraining: reproduce head positions with eyes closed. (b) Eye–head coordination: track a moving target with combined eye and head movement. (c) Perturbation-based balance training: maintain standing balance in response to gentle, unpredictable perturbations. Train 3 times weekly for 4 weeks (45–60 minutes per session). Add home head-repositioning exercises with a laser wall target, 5 minutes twice daily (Cheng et al., 2020).

Evidence. In postoperative DCM patients, postural sway and dynamic balance improved, with Berg Balance Scale gains of 4–8 points and reduced fall risk (Cheng et al., 2020). JPE decreased 2–4° (Rahnama et al., 2023). Gait speed improved 0.15–0.2 m/s (Cheng et al., 2020). Certainty of evidence (GRADE): Low: one small DCM RCT.

3.5 Aerobic Conditioning

Aerobic conditioning counters systemic deconditioning from chronic spinal cord dysfunction. Direct DCM evidence is lacking.

Intervention Protocol. Walk 30 minutes daily or cycle at moderate intensity (Borg Rating of Perceived Exertion 11–13), 5 days weekly, with gradual progression. Use recumbent cycling or water-based walking if gait is impaired.

Evidence. Exercise confers general cardiovascular, metabolic, and anti-inflammatory benefits (Gleeson et al., 2011). Structured exercise reduces pain and disability in chronic neck disorders (Gross et al., 2016). Whether these gains translate to DCM remains unknown. Certainty of evidence (GRADE): Low: no DCM-specific randomized trials.

3.6 Flexion-Based Exercises

Cervical flexion widens the spinal canal. The ligamentum flavum tightens, and the anteroposterior (AP) canal diameter increases 1–2 mm versus neutral (2–3 mm versus extension) (Muhle et al., 1998).

Flexion-based exercise, therefore, offers dynamic decompression, mainly for stenosis-predominant disease.

Intervention Protocol. (a) Chin tucks: gentle posterior translation of the head. (b) Seated forward bending: controlled cervical and upper thoracic flexion. (c) Supine knee-to-chest: passive lumbar and lower cervical flexion. Perform 10 repetitions, 3 times daily, integrated into daily activities.

Evidence. Biomechanical studies confirm the canal changes with flexion (Muhle et al., 1998). Clinical outcome data in DCM are limited, so the benefit is unproven in controlled studies. Certainty of evidence (GRADE): Low: strong biomechanical rationale, limited DCM-specific data.

3.7 Postural Correction

Postural correction aims to restore normal cervical sagittal alignment and reduce forward-head posture; postural exercise programs improve craniovertebral angle, pain, and disability in people with forward-head posture (Kang et al., 2021).

Intervention Protocol. (a) Thoracic extension over a foam roller, 2–3 minutes daily. (b) Scapular retraction with chin tuck, 10 repetitions 3 times daily. (c) Wall angels, 10 repetitions once daily. (d) Postural awareness training during sitting, standing, and walking. Continue for 8–12 weeks with maintenance.

Evidence. One RCT reported improvements in craniovertebral angle, pain, and disability in office workers with forward-head posture (Kang et al., 2021). Certainty of evidence (GRADE): Low: one RCT in a non-DCM population.

3.8 Multimodal Comprehensive Rehabilitation

Multimodal rehabilitation combines isometric strengthening, DCF training, stabilization, proprioceptive exercise, postural correction, and aerobic conditioning. It produced the largest functional gains in this review.

Intervention Protocol. Provide supervised sessions 2–3 times weekly (60–90 minutes), plus daily home exercise, for 8–12 weeks. Follow with a maintenance phase.

Evidence. Catz et al. (2024) reported a 22-point improvement on the Spinal Cord Independence Measure III (SCIM-III) after comprehensive inpatient rehabilitation; 70% of the improvement was attributed to enhanced ability realization. Postoperative multimodal rehabilitation improves outcomes after cervical spine surgery (Sakaguchi et al., 2024; Badran et al., 2018; Montpetit et al., 2026; Uehara et al., 2022). Among 66 postoperative DCM patients, occupational therapy (functional training) improved mJOA more than physical therapy (cervical range-of-motion and stabilization): $\beta = 1.6$ (95% confidence interval [CI] 0.28–3.0) versus $\beta = -0.32$ (95% CI − 1.5 to 0.9) (Rahman et al., 2024). Task-specific functional training may outperform impairment-based exercise after surgery. Certainty of evidence (GRADE): Moderate: consistent findings across study designs; no large randomized trials.

3.9 Technology-Assisted Rehabilitation

Technology-assisted adjuncts, including repetitive transcranial magnetic stimulation (rTMS), robotic exoskeleton training (Hybrid Assistive Limb, HAL), and virtual reality (VR), are promising but currently supported only by preliminary, small-sample evidence.

Intervention Protocol. rTMS: 10 motor-cortex stimulation sessions over two weeks, combined with physiotherapy (Farrokhi et al., 2024). HAL: exoskeleton-assisted shoulder and elbow training after postoperative C5 palsy (Kubota et al., 2021). VR: home-based cervical training with a head-mounted display and real-time feedback (Yen et al., 2025).

Evidence. rTMS with physiotherapy improved mJOA recovery more than physiotherapy alone ($p = 0.002$; Farrokhi et al., 2024). HAL training improved manual muscle testing grades from 1–2 to 3–4 in one patient with C5 palsy (Kubota et al., 2021). VR home training matched face-to-face therapy in terms of range of motion and pain (Yen et al., 2025). Certainty of evidence (GRADE): Very low: small or single-case studies.

4. Mechanistic Interpretation for Exercise-based Rehabilitation (RQ3)

Addressing RQ3, four pathways may link exercise to functional improvement: biomechanical, vascular and metabolic, neuroplastic and sensorimotor, and muscular and anti-inflammatory (Fig. 4). The sensorimotor and neuroplastic pathway has the strongest direct support, with measurable gains in balance, gait, and dexterity. The biomechanical, vascular, metabolic, muscular, and anti-inflammatory pathways remain biologically plausible, but their contributions are inferred from physiology or adjacent populations rather than demonstrated in DCM trials. The clinical role follows directly: exercise is an adjunct to surveillance or surgery that supports functional recovery, not a structural treatment, and it must not delay surgical assessment in progressive or severe disease.

4.1 Biomechanical Pathway

Postural correction restores normal cervical sagittal alignment, a key predictor of DCM outcomes (Iyer et al., 2016), with lordosis gains of 5–10° (McAviney et al., 2005). In principle, lordosis restoration positions the cord posteriorly within the canal, maximizing available subarachnoid space and reducing contact with anterior compressive pathology (Nouri et al., 2015). Lordosis may be associated with a more favorable canal geometry in some postoperative or modeled settings. However, the MRI evidence does not show that simply increasing cervical lordosis consistently increases spinal canal diameter (Jha et al., 2018).

Flexion-Based Decompression. Cervical flexion increases AP canal diameter by 1–2 mm by stretching the ligamentum flavum taut, eliminating its inward buckling; extension narrows the canal by 2–3 mm through ligamentum flavum infolding and posterior element approximation (Muhle et al., 1998). Flexion-

biased exercises (chin tucks, seated forward lean) are therefore proposed as therapeutic for stenosis-predominant disease, whereas end-range cervical extension is generally avoided in DCM.

Dynamic Stabilization. Strengthening deep cervical muscles reduces segmental translation during movement, decreasing repetitive shear microtrauma to the cord (Karadimas et al., 2013). This may slow progression in mild DCM managed conservatively.

4.2 Vascular and Metabolic Pathway

Chronic spinal cord compression can impair arterial inflow, venous drainage, and microvascular integrity. These disturbances may contribute to ischemia, oxidative stress, neuroinflammation, demyelination, and progressive axonal injury (Karadimas et al., 2013; Kalsi-Ryan et al., 2013; Tu et al., 2021). Aerobic and resistance exercise can improve systemic cardiovascular and metabolic health and produce anti-inflammatory adaptations in general populations (Gleeson et al., 2011). Vascular and metabolic effects should therefore be regarded as biologically plausible, as are the established disease-modifying effects of exercise in DCM.

4.3 Neuroplastic and Sensorimotor Pathway

DCM leaves the nervous system in a partially impaired yet still plastic state. Exercise can exploit this residual reserve by improving sensorimotor integration, proprioceptive accuracy, reactive stepping, and task-specific motor control, resulting in better walking, balance, and hand function (Kleim & Jones, 2008).

In 15 postoperative DCM patients, four weeks of perturbation-based balance training enhanced postural sway, perturbation responses, gait speed, and Timed Up and Go performance (Cheng et al., 2020). Proprioceptive feedback can decrease repositioning errors (Rahnama et al., 2023). Targeted hand training also showed benefits. A single-arm study of 22 postoperative patients found that four weeks of virtual-reality finger training reduced Jebsen–Taylor Hand Function Test completion time by 15.21 seconds post-training and 17.84 seconds at follow-up. Both values surpassed the minimal clinically important difference (Raju et al., 2025).

The neuroplastic/sensorimotor pathway is best framed as functional compensation with measurable gains: strongest for balance, gait, and dexterity; weaker for broad disability scores (NDI/mJOA); and no evidence of reversing stenosis itself (Catz et al., 2024).

4.4 Muscular and Anti-Inflammatory Pathway

Strengthening and task-specific rehabilitation may improve muscle force, endurance, balance, mobility, and daily functioning. In 116 postoperative patients with DCM, comprehensive inpatient rehabilitation increased the Spinal Cord Injury Ability Realization Measurement Index from 57 to 78. However, the retrospective design and absence of a control group limit causal interpretation (Catz et al., 2024). In a randomized trial of 40 patients following anterior cervical discectomy and fusion, cervical-stabilizer training and usual care produced similar improvements in pain, disability, strength, and endurance

(McFarland et al., 2020). Because this population was not limited to patients with DCM, the evidence is indirect.

Exercise has systemic anti-inflammatory effects in general populations (Gleeson et al., 2011). In contrast, inflammation and disruption of the blood–spinal cord barrier contribute to the pathophysiology of DCM (Tu et al., 2021).

Exercise can enhance strength, endurance, fatigue resistance, balance, walking, and reduce disability. However, these are mainly functional compensations rather than structural cures. The anti-inflammatory pathway is biologically plausible, but existing DCM/CSM exercise studies do not directly measure its effectiveness.

5. Clinical Implications and Safety

Exercise should be integrated with severity-based management, not offered as a stand-alone cure. For stable mild DCM, guidelines allow surgery or a supervised trial of structured rehabilitation with close follow-up (Fehlings et al., 2017). Nonoperative cohorts show variable trajectories; deterioration or later surgery remains possible (Kim et al., 2023; Martin et al., 2021; Rhee et al., 2013; Rhee et al., 2017; Tetreault et al., 2017). Moderate, severe, or progressive DCM warrants prompt surgical assessment. Rehabilitation is valuable before surgery for conditioning and after surgery for balance, gait, upper-limb function, independence, and return to activity (Boerger et al., 2022).

A defensible program is individualized and multimodal (Hejrati et al., 2022): task-specific gait and balance training; graded limb strengthening; low-load cervical motor control in neutral ranges; aerobic conditioning adapted to fall risk; and monitored home practice. Dosage should reflect neurological status, surgical precautions, comorbidities, baseline capacity, and symptom response, rather than neck-pain protocols.

New or worsening weakness, hand dysfunction, gait imbalance, falls, numbness, sphincter symptoms, or electric-shock sensations require stopping the provoking activity and urgent reassessment. Forceful cervical manipulation, unsupervised end-range loading, and exercises that reproduce neurological symptoms are inappropriate. Rehabilitation must not delay surgical review when deterioration occurs.

6. Limitations

The evidence is heterogeneous, mixing primary and secondary reports, which risks overlap and double-counting. DCM-specific trials are few. Many studies are postoperative, small, non-randomized, or confounded by spontaneous recovery and surgical decompression. Intervention descriptions, adherence, adverse-event reporting, and follow-up varied.

7. Conclusion

This systematic review clarifies the clinical efficacy, modality distribution, and biological mechanisms of exercise-based rehabilitation in DCM:

1. **Effectiveness (RQ1)**: Exercise-based rehabilitation significantly improves physical function, dynamic balance, gait capacity, and daily independence in patients with stable mild DCM and those recovering from surgical decompression. However, its impact on core neurological impairment scores (e.g., mJOA) remains modest and highly variable.
2. **Modalities (RQ2)**: Multimodal, task-specific functional rehabilitation and targeted balance/proprioceptive training demonstrate the strongest direct evidence in DCM populations. In contrast, widely prescribed modalities such as isolated isometric strengthening, deep cervical flexor training, and postural correction rely primarily on indirect evidence.
3. **Mechanisms and Clinical Role (RQ3)**: Benefits are mediated predominantly through neuroplastic sensorimotor adaptation and functional muscle compensation, rather than structural spinal cord decompression or canal enlargement. Consequently, exercise therapy serves as a functional adjunct, not a replacement for timely surgery in progressive disease.

Future trials should enroll well-phenotyped DCM populations, stratify by severity and surgical status, standardize exercise dose and comparator care, monitor adverse events, and report mJOA, gait, dexterity, balance, independence, quality of life, and subsequent surgery.

Declarations

Conflicts of Interest

The author declares no conflicts of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data Availability

This article is a systematic review of previously published literature; no new datasets were generated or analyzed in this study. All included studies are cited in the references.

References

1. Badran A, Davies BM, Bailey HM, Kalsi-Ryan S, Kotter MR (2018) Is there a role for postoperative physiotherapy in degenerative cervical myelopathy? A systematic review. Clin Rehabil 32(9):1169–1174. https://doi.org/10.1177/0269215518766229

2. Blanpied PR, Gross AR, Elliott JM, Devaney LL, Clewley D, Walton DM et al (2017) Neck pain: Revision 2017. J Orthop Sports Phys Therapy 47(7):A1–A83. https://doi.org/10.2519/jospt.2017.0302
3. Boerger TF, Hyngstrom AS, Furlan JC, Kalsi-Ryan S, Curt A, Kwon BK et al (2022) Developing peri-operative rehabilitation in degenerative cervical myelopathy [AO Spine RECODE-DCM Research Priority Number 6]: An unexplored opportunity? Global Spine J 12(1 Suppl):97S–108S. https://doi.org/10.1177/21925682211050925
4. Catz A, Watts Y, Amir H, Front L, Gelernter I, Michaeli D et al (2024) The role of comprehensive rehabilitation in the care of degenerative cervical myelopathy. Spinal Cord 62(5):200–206. https://doi.org/10.1038/s41393-024-00965-y
5. Cervellini M, Feller D, Maselli F, Rossettini G, Cook C, Tabrah J et al (2025) Understanding degenerative cervical myelopathy in musculoskeletal practice. J Man Manipulative Therapy 33(3):207–223. https://doi.org/10.1080/10669817.2025.2465728
6. Cheng YS, Chien A, Lai DM, Lee YY, Cheng CH, Wang SF et al (2020) Perturbation-based balance training in postoperative individuals with degenerative cervical myelopathy. Front Bioeng Biotechnol 8:108. https://doi.org/10.3389/fbioe.2020.00108
7. Davies BM, Mowforth O, Wood H, Karouzos I, Kotter MRN (2022) Improving awareness could transform outcomes for patients with degenerative cervical myelopathy [AO Spine RECODE-DCM Research Priority Number 1]. Global Spine J 12(1 Suppl):28S–38S. https://doi.org/10.1177/21925682211050927
8. Farrokhi MR, Salehi S, Nejabat N, Safdari M, Ramezani Abadeh H (2024) Beneficial effect of repetitive transcranial magnetic stimulation combined with physiotherapy after cervical spondylotic myelopathy surgery. J Clin Neurophysiol 41(2):182–187. https://doi.org/10.1097/WNP.0000000000000949
9. Fehlings MG, Tetreault LA, Wilson JR, Skelly AC (2013a) Cervical spondylotic myelopathy: Current state of the art and future directions. Spine, 38(22 Suppl 1), S1–S8. https://doi.org/10.1097/BRS.0b013e3182a7e9e0
10. Fehlings MG, Wilson JR, Kopjar B, Yoon ST, Arnold PM, Massicotte EM et al (2013b) Efficacy and safety of surgical decompression in patients with cervical spondylotic myelopathy: Results of the AO Spine North America prospective multi-center study. J Bone Joint Surg 95(18):1651–1658. https://doi.org/10.2106/JBJS.L.00589
11. Fehlings MG, Tetreault LA, Riew KD, Middleton JW, Aarabi B, Arnold PM et al (2017) A clinical practice guideline for the management of patients with degenerative cervical myelopathy: Recommendations for patients with mild, moderate, and severe disease and nonmyelopathic patients with evidence of cord compression. Global Spine J 7(3 Suppl):70S–83S. https://doi.org/10.1177/2192568217701914
12. Gallego Izquierdo T, Pecos-Martin D, Lluch Girbés E, Plaza-Manzano G, Rodríguez Caldentey R, Mayor Melús R et al (2016) Comparison of cranio-cervical flexion training versus cervical

proprioception training in patients with chronic neck pain: A randomized controlled clinical trial. J Rehabil Med 48(1):48–55. https://doi.org/10.2340/16501977-2034

13. Gleeson M, Bishop NC, Stensel DJ, Lindley MR, Mastana SS, Nimmo MA (2011) The anti-inflammatory effects of exercise: Mechanisms and implications for the prevention and treatment of disease. Nat Rev Immunol 11(9):607–615. https://doi.org/10.1038/nri3041
14. Gross A, Kay TM, Paquin JP, Blanchette S, Lalonde P, Christie T et al (2016) Exercises for mechanical neck disorders. Cochrane Database Syst Reviews 2016(1):CD004250. https://doi.org/10.1002/14651858.CD004250.pub5
15. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schünemann HJ (2008) GRADE: An emerging consensus on rating quality of evidence and strength of recommendations. BMJ 336(7650):924–926. https://doi.org/10.1136/bmj.39489.470347.AD
16. Hejrati N, Moghaddamjou A, Marathe N, Fehlings MG (2022) Degenerative cervical myelopathy: Towards a personalized approach. Can J Neurol Sci 49(6):729–740. https://doi.org/10.1017/cjn.2021.214
17. Iyer S, Nemani VM, Nguyen J, Elysee J, Burapachaisri A, Ames CP, Kim HJ (2016) Impact of cervical sagittal alignment parameters on neck disability. Spine 41(5):371–377. https://doi.org/10.1097/BRS.0000000000001221
18. Jha SC, Miyazaki M, Tsumura H (2018) Kinetic change of spinal cord compression on flexion-extension magnetic resonance imaging in cervical spine. Clin Neurol Neurosurg 174:86–91. https://doi.org/10.1016/j.clineuro.2018.09.017
19. Jiang L, Xu Y, Yang Z, Li P, Dong Y, Yang G (2025) Global trends in cervical spondylosis research: A bibliometric analysis based on the Web of Science. Front Neurol 16:1541459. https://doi.org/10.3389/fneur.2025.1541459
20. Jull G, Sterling M, Falla D, Treleaven J, O'Leary S (2008) Whiplash, headache, and neck pain: Research-based directions for physical therapies. Churchill Livingstone
21. Kalsi-Ryan S, Karadimas SK, Fehlings MG (2013) Cervical spondylotic myelopathy: The clinical phenomenon and the current pathobiology of an increasingly prevalent and devastating disorder. Neuroscientist 19(4):409–421. https://doi.org/10.1177/1073858412467377
22. Kang NY, Im SC, Kim K (2021) Effects of a combination of scapular stabilization and thoracic extension exercises for office workers with forward head posture on the craniovertebral angle, respiration, pain, and disability: A randomized-controlled trial. Turkish J Phys Med Rehabilitation 67(3):291–299. https://doi.org/10.5606/tftrd.2021.6397
23. Karadimas SK, Erwin WM, Ely CG, Dettori JR, Fehlings MG (2013) Pathophysiology and natural history of cervical spondylotic myelopathy. Spine, 38(22 Suppl 1), S21–S36. https://doi.org/10.1097/BRS.0b013e3182a7f2c3
24. Kim MW, Kang CN, Choi SH (2023) Update of the natural history, pathophysiology, and treatment strategies of degenerative cervical myelopathy: A narrative review. Asian Spine J 17(1):213–221. https://doi.org/10.31616/asj.2022.0440

25. Kleim JA, Jones TA (2008) Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. J Speech Lang Hear Res 51(1):S225–S239. https://doi.org/10.1044/1092-4388(2008/018)
26. Kubota S, Kadone H, Shimizu Y, Koda M, Miura K, Takahashi H et al (2021) Adjustment effect during shoulder abduction training with the Hybrid Assistive Limb in a patient with postoperative C5 palsy. J Clin Neurosci 88:197–204. https://doi.org/10.1016/j.jocn.2021.03.042
27. Martin AR, Kalsi-Ryan S, Akbar MA, Rienmuller AC, Badhiwala JH, Wilson JR et al (2021) Clinical outcomes of nonoperatively managed degenerative cervical myelopathy: An ambispective longitudinal cohort study in 117 patients. J Neurosurgery: Spine 34(6):821–829. https://doi.org/10.3171/2020.9.SPINE201395
28. McAviney J, Schulz D, Bock R, Harrison DE, Holland B (2005) Determining the relationship between cervical lordosis and neck complaints. J Manip Physiol Ther 28(3):187–193. https://doi.org/10.1016/j.jmpt.2005.02.015
29. McFarland C, Wang-Price S, Gordon B, Danielson J, Crutchfield K, Medley A, Roddey T (2020) A comparison of clinical outcomes between early cervical spine stabilizer training and usual care in individuals following anterior cervical discectomy and fusion. Rehabilitation Research and Practice, 2020, Article 5946152. https://doi.org/10.1155/2020/5946152
30. Montpetit C, Kobaisi A, Lantz JM, Chauhan RV, Anderson DB, Fortin M et al (2026) The effect of postoperative rehabilitation on outcomes in patients with degenerative cervical myelopathy (DCM): A systematic review. Brain Spine 6:105956. https://doi.org/10.1016/j.bas.2026.105956
31. Muhle C, Weinert D, Falliner A, Wiskirchen J, Metzner J, Baumer M et al (1998) Dynamic changes of the spinal canal in patients with cervical spondylosis at flexion and extension using magnetic resonance imaging. Invest Radiol 33(8):444–449. https://doi.org/10.1097/00004424-199808000-00004
32. Nouri A, Tetreault L, Singh A, Karadimas SK, Fehlings MG (2015) Degenerative cervical myelopathy: Epidemiology, genetics, and pathogenesis. Spine 40(12):E675–E693. https://doi.org/10.1097/BRS.0000000000000913
33. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al (2021) The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 372:n71. https://doi.org/10.1136/bmj.n71
34. Rahman M, Banerjee A, Yang Y, Annyapu E, DeGroot AL, Best B, Braza DW, Wang MC, Vedantam A (2024) Impact of postsurgical rehabilitation on outcomes for degenerative cervical myelopathy. J Neurosurgery: Spine 41(2):167–173. https://doi.org/10.3171/2024.2.spine231170
35. Rahnama L et al (2023) Effects of two exercise programs on neck proprioception in patients with chronic neck pain: A preliminary randomized clinical trial. Med Sci 11(3):56. https://doi.org/10.3390/medsci11030056
36. Raju VB, Hauer R, Ghassemi M, Banerjee A, Kamper D, Schmit BD, Vedantam A (2025) Virtual reality-based training to augment recovery of hand dexterity after surgery for degenerative cervical

myelopathy. Sci Rep 15:22785. https://doi.org/10.1038/s41598-025-05793-5

37. Rhee JM, Shamji MF, Erwin WM, Bransford RJ, Yoon ST, Smith JS et al (2013) Nonoperative management of cervical myelopathy: A systematic review. Spine 38(22 Suppl 1):S55–S67. https://doi.org/10.1097/BRS.0b013e3182a7f41d
38. Rhee J, Tetreault LA, Chapman JR, Wilson JR, Smith JS, Martin AR et al (2017) Nonoperative versus operative management for the treatment of degenerative cervical myelopathy: An updated systematic review. Global Spine J 7(3 Suppl):35S–41S. https://doi.org/10.1177/2192568217703083
39. Sadeghi A, Rostami M, Ameri S, Moghaddam K, Moghaddam AK, Z., Zeraatchi A (2022) Effectiveness of isometric exercises on disability and pain of cervical spondylosis: A randomized controlled trial. BMC Sports Sci Med Rehabilitation 14., Article 108. https://doi.org/10.1186/s13102-022-00500-7
40. Sakaguchi T, Heyder A, Tanaka M, Uotani K, Omori T, Kodama Y et al (2024) Rehabilitation to improve outcomes after cervical spine surgery: Narrative review. J Clin Med 13(18):5363. https://doi.org/10.3390/jcm13185363
41. Sundaramurthy SK, Lal N, Rajalakshmi D (2012) Effect of exercise program on the rehabilitation of patients with cervical spondylotic myelopathy. Neurosci Med 3(1):54–59. https://doi.org/10.4236/nm.2012.31008
42. Tetreault LA, Rhee J, Prather H, Kwon BK, Wilson JR, Martin AR et al (2017) Change in function, pain, and quality of life following structured nonoperative treatment in patients with degenerative cervical myelopathy: A systematic review. Global Spine J 7(3 Suppl):42S–52S. https://doi.org/10.1177/2192568217700397
43. Thompson K, Travers H, Ngan A, Reed T, Shahsavarani S, Verma RB (2024) Updates in current concepts in degenerative cervical myelopathy: A systematic review. J Spine Surg 10(2):313–326. https://doi.org/10.21037/jss-23-123
44. Tu J, Vargas Castillo J, Das A, Diwan AD (2021) Degenerative cervical myelopathy: Insights into its pathobiology and molecular mechanisms. J Clin Med 10(6):1214. https://doi.org/10.3390/jcm10061214
45. Uehara M et al (2022) A randomized controlled trial for the intervention effect of early exercise therapy on axial pain after cervical laminoplasty. Spine Surg Relat Res 6(2):123–132. https://doi.org/10.22603/ssrr.2021-0110
46. Yen L-W, Chen H-B, Rezaei A, Lien H-Y, Nikkhoo M, Cheng C-H (2025) A comparison of conventional intervention and home-based approach with head-mounted device for cervical spondylotic myelopathy after surgery. Sci Rep 15(1). https://doi.org/10.1038/s41598-025-91555-2. Article 91555
47. Ylinen J, Takala EP, Nykänen M, Häkkinen A, Mälkiä E, Pohjolainen T et al (2003) Active neck muscle training in chronic neck pain in women: A randomized controlled trial. JAMA 289(19):2509–2516. https://doi.org/10.1001/jama.289.19.2509

Figures

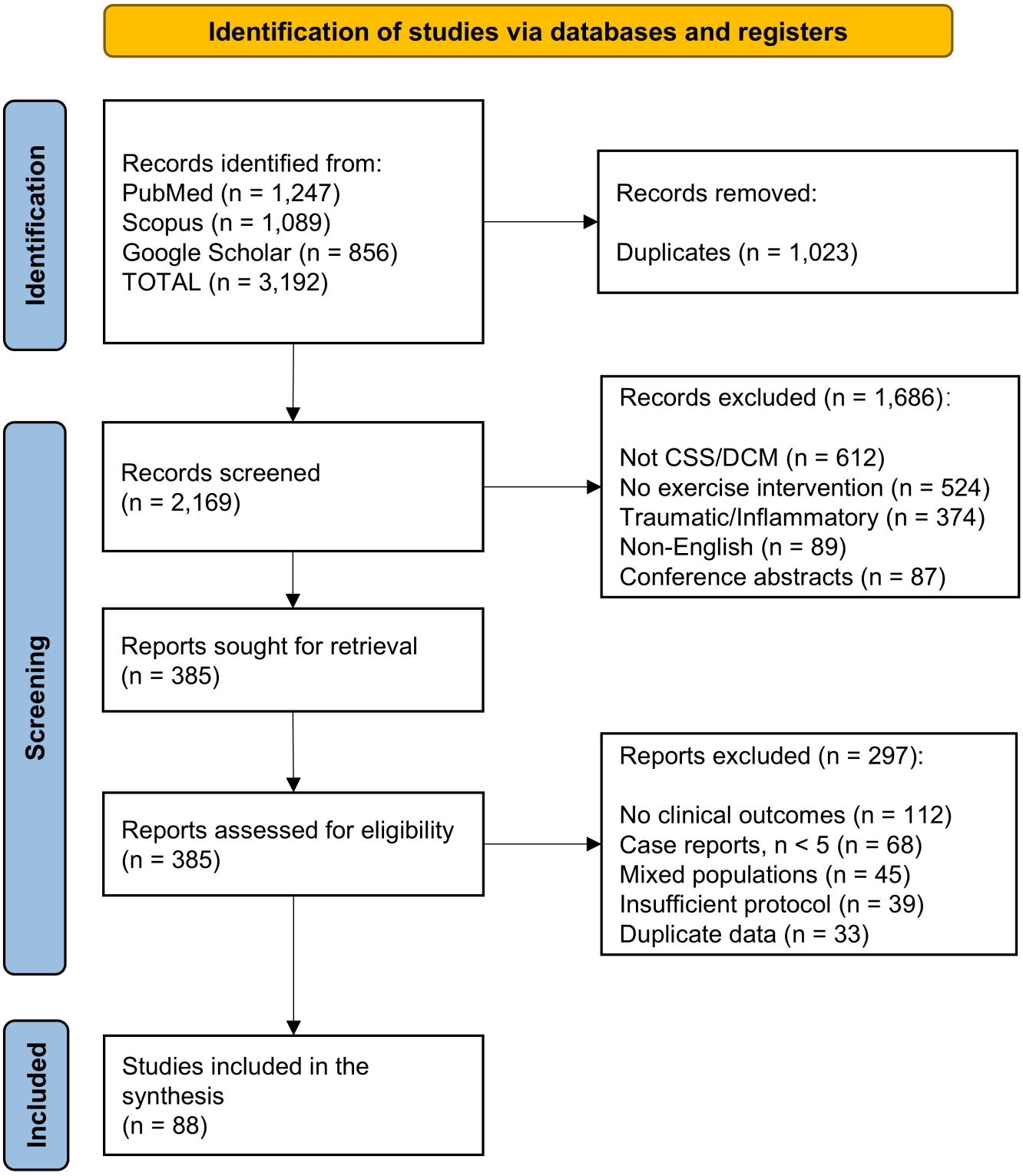


Figure 1

PRISMA 2020 flow diagram illustrating the study selection process. From 3,192 initial records identified across three electronic databases, 88 reports met all eligibility criteria and were included in the

systematic review and evidence synthesis. *Abbreviations:* CSS, cervical spinal stenosis; DCM, degenerative cervical myelopathy

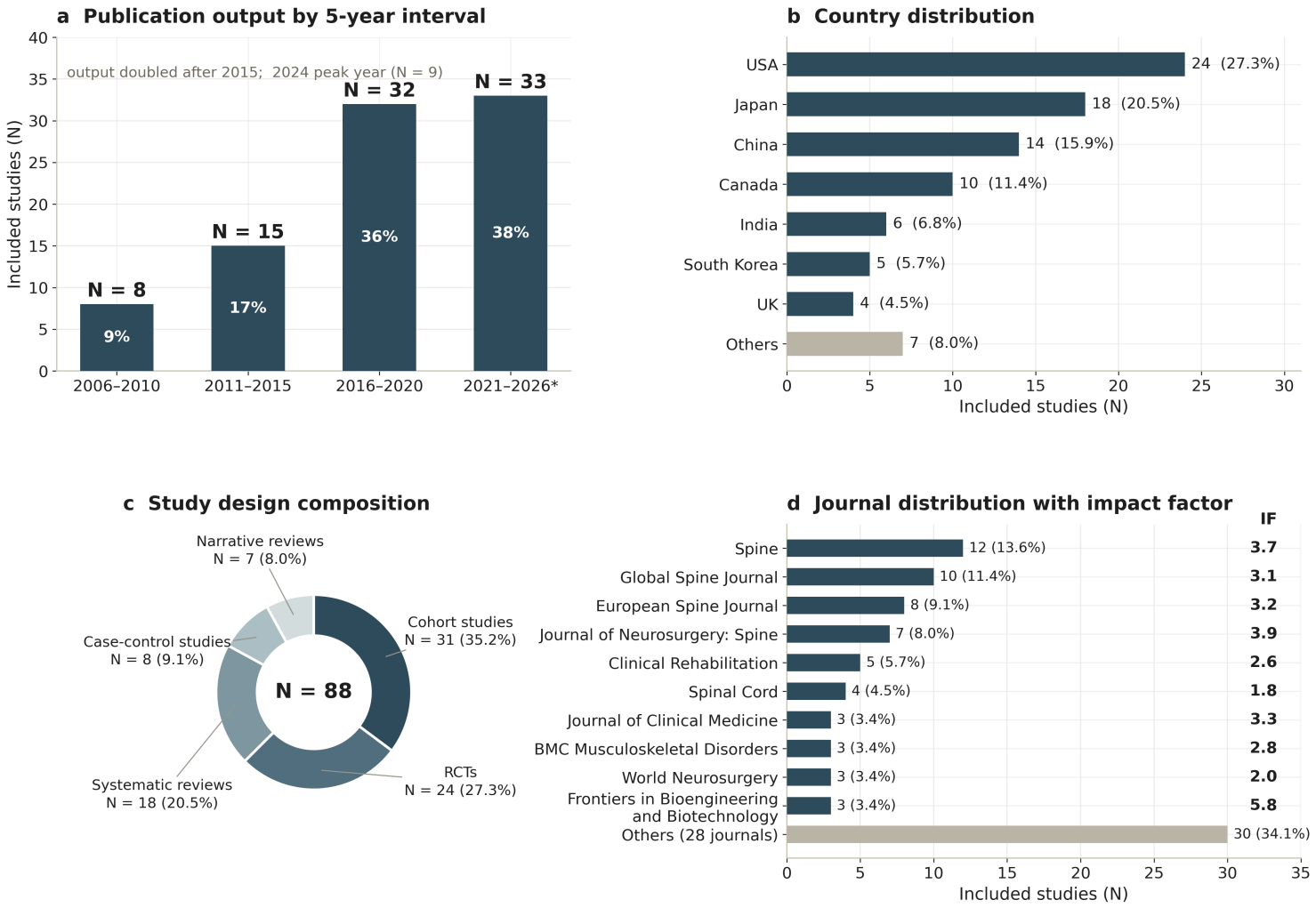


Figure 2

Bibliometric characterization of the included literature (N = 88, 2006–2026). **(a)**Distribution of publication output across 5-year intervals. **(b)**Geographic distribution by author affiliation. **(c)** Proportional composition of study designs. **(d)** Top contributing journals displaying primary publication counts alongside Clarivate Journal Impact Factors (IF).

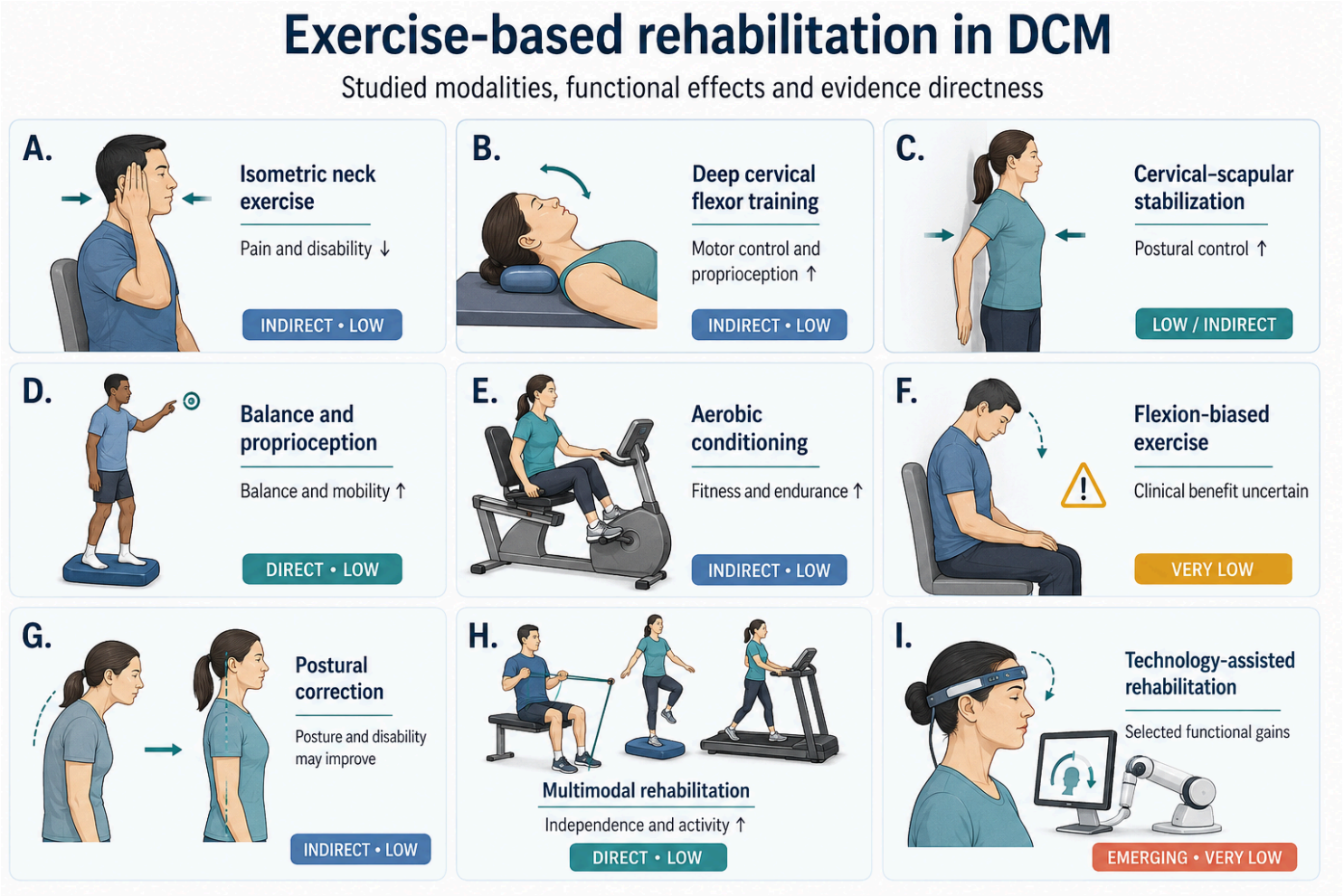


Figure 3

Taxonomy of exercise-based rehabilitation modalities in degenerative cervical myelopathy (DCM). Evidence labels follow GRADE: “indirect” indicates that the studies did not enroll a separable DCM population; “low” and “very low” reflect small, non-randomized, heterogeneous, or postoperative evidence.

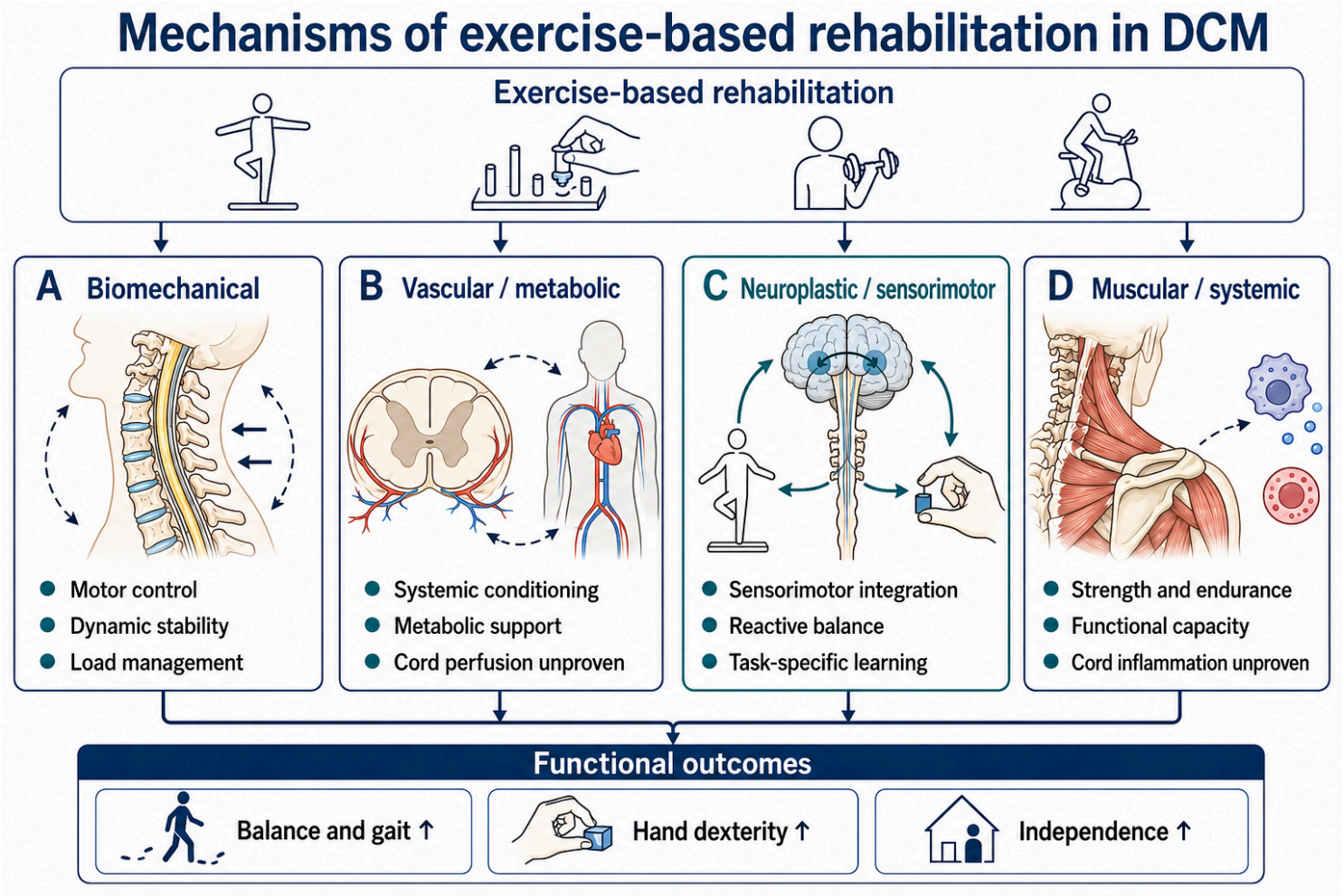


Figure 4

Conceptual mechanistic framework linking exercise-based rehabilitation to functional recovery in DCM. Four distinct biological and physiological pathways—biomechanical, vascular/metabolic, neuroplastic/sensorimotor, and muscular/anti-inflammatory—mediate adaptations that improve balance, gait capacity, upper-limb dexterity, and task independence.