Thoracic Mobility and Flexibility Exercise Interventions for Adults with Neck Pain: A Scoping Review of Intervention Characteristics, Outcome Measures and the Extent of Cervical Proprioception Assessment

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ABSTRACT

Background: Neck pain is one of the commonest musculoskeletal disorders worldwide (an age-standardised prevalence of 27.0 per 1,000 in 2019), and restricted thoracic mobility is considered a contributing factor. Existing syntheses focus on passive thoracic manipulation; no review has mapped the active thoracic mobility/flexibility exercise literature or determined whether cervical proprioception (joint position error, JPE) has been assessed within it.

Objective: To map the characteristics of thoracic mobility/flexibility exercise interventions in adults with neck pain, the outcome domains and instruments reported, and the extent to which cervical proprioception has been measured.

Eligibility criteria: Studies of adults (≥18 years) with any neck pain presentation receiving active thoracic mobility/flexibility exercise, alone or within multimodal care; any study design with data; English; published 2000–2026. Cervical proprioception was a charting target, not an eligibility requirement.

Sources of evidence: PubMed (NCBI E-utilities, including sensitivity probe searches) and the ClinicalTrials.gov registry, supplemented by supplementary searches (Google Scholar; PEDro- and Scopus-indexed surrogate web sweeps; the Iranian Registry of Clinical Trials) and hand searching; searched 19 and 22 September 2026.

Charting methods: Records were screened against a hierarchical exclusion framework (codes E1–E12); data were charted on a standardised form covering population, intervention, comparator, outcomes and, wherever present, the method and time points of proprioception (JPE) assessment.

Results: Of 618 records (377 databases, 1 hand search, 240 registry), 12 published reports of 11 trials (428 participants; 10 randomised controlled trials and 1 controlled trial with unclear allocation; 2000–2026) and 2 registered trials were included. Interventions ranged from single-session thoracic self-mobilisation to 12-week multimodal programmes. Pain was the most frequently reported domain (10/11 trials), followed by range of motion (9/11) and posture/alignment (6/11). Cervical proprioception (JPE) was assessed in only 2/11 trials — both using laser-based JPE tests — and is absent from the remainder of the mapped evidence.

Conclusion: The thoracic mobility/flexibility exercise evidence base in neck pain is small and heterogeneous, and cervical proprioception is seldom measured. Outcome mapping identifies a clear gap: future trials — including interventions developed from this review — should incorporate validated JPE assessment alongside pain and function outcomes.

Keywords: neck pain; cervicalgia; thoracic spine; mobility exercise; flexibility; scoping review; proprioception; joint position error; PRISMA-ScR

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INTRODUCTION

Neck pain is among the most prevalent musculoskeletal conditions globally, with an age-standardised prevalence of 27.0 per 1,000 population reported for 2019, and a large proportion of affected individuals fail to recover fully after an acute episode [25]. The cervical and thoracic regions are biomechanically and functionally coupled, and restricted thoracic mobility is widely proposed as a contributing factor to neck pain and its persistence [13, 26].

The synthesis literature to date has concentrated on passive thoracic interventions: systematic reviews and meta-analyses of thoracic spine manipulation report short-term improvements in pain, cervical range of motion (ROM) and disability [13, 3, 22], and a 2024 systematic review found thoracic manipulation effective for pain, ROM and disability without serious adverse events [26]. Clinical practice guidance likewise recommends thoracic manipulation combined with exercise for cervical and cervicothoracic presentations [2]. However, the exercise component of these recommendations — specifically active thoracic mobility and flexibility exercise — has never been mapped as a distinct intervention category.

In parallel, a well-developed literature documents cervical sensorimotor impairment in neck pain, with joint position error (JPE) the most widely used clinical index of cervical proprioception [20, 15, 17]. JPE is elevated in people with chronic idiopathic neck pain and correlates with pain intensity in cervical spondylosis [15, 17]. Whether trials of thoracic mobility/flexibility exercise assess cervical proprioception is unknown; no scoping review has addressed this. Such a map is a prerequisite for developing new interventions targeting thoracic mobility with sensorimotor outcomes. The objective of this scoping review was therefore to map (i) the characteristics of thoracic mobility/flexibility exercise interventions in adults with neck pain, (ii) the outcome domains and instruments reported, and (iii) the extent to which cervical proprioception (JPE) has been assessed.

METHODS

Protocol and registration

This review was conducted and reported in accordance with the Arksey and O'Malley methodological framework as operationalised by JBI guidance [1, 16] and the PRISMA extension for Scoping Reviews (PRISMA-ScR) [24]. A formal protocol was not prospectively registered; the review question, eligibility criteria and charting form were finalised a priori by the review team (available on request).

Eligibility criteria

Using the Population-Concept-Context (PCC) framework: the population was adults (≥18 years) with any neck pain presentation (mechanical/non-specific, chronic, acute/subacute, cervicogenic, whiplash-associated). The concept was any active thoracic mobility or flexibility exercise intervention (self-mobilisation, mobility or flexibility drills, thoracic stretching, ROM exercise, foam-roller work), standalone or as a component of multimodal care; cervical proprioception/JPE was a mapping target, not a requirement. The context was any setting, country or provider. Systematic reviews and meta-analyses were tagged for reference mining rather than treated as data sources. Non-English publications and publications before 2000 were excluded (feasibility limits). A hierarchical exclusion framework with twelve reason codes (E1 animal/in vitro; E2 paediatric; E3 ineligible condition such as radiculopathy, myelopathy, inflammatory arthropathy, post-surgical or neoplastic necks; E4 no thoracic mobility/flexibility exercise arm (including manipulation-only or cervical-only-exercise trials); E5 passive/device-only interventions; E6 laboratory/biomechanical studies without an exercise intervention; E7 review/meta-analysis (reference mining); E8 narrative review, editorial or comment; E9 retracted; E10 duplicate; E11 non-English; E12 pre-2000) was applied in that order, so that each record carried a single primary exclusion code.

Search strategy

PubMed was searched on 19 September 2026 via the NCBI E-utilities API (esearch followed by full-record efetch), with the following query (filters: English, humans, 2000/01/01–present): (neck pain[Title/Abstract] OR cervicalgia[Title/Abstract] OR cervical pain[Title/Abstract] OR cervicogenic*[Title/Abstract] OR whiplash[Title/Abstract] OR Neck Pain[Mesh] OR Whiplash Injuries[Mesh]) AND (thoracic[Title/Abstract] OR

"upper back"[Title/Abstract] OR "mid-back"[Title/Abstract] OR "mid back"[Title/Abstract] OR midthoracic[Title/Abstract] OR dorsal[Title/Abstract] OR dorsalgia[Title/Abstract] OR T1–T12[Title/Abstract]) AND (Exercise[MeSH] OR Stretching[MeSH] OR "Range of Motion, Articular"[MeSH] OR exercis*[Title/Abstract] OR stretch*[Title/Abstract] OR mobilit*[Title/Abstract] OR mobiliz*[Title/Abstract] OR mobilis*[Title/Abstract] OR self-mobiliz*[Title/Abstract] OR "foam roll"*[Title/Abstract] OR "range of motion"[Title/Abstract] OR ROM[Title/Abstract] OR flexib*[Title/Abstract]) AND English[Language] AND humans[Filter] AND "2000/01/01"[Date - Publication] : "3000"[Date - Publication]

No outcome or proprioception terms were included in the search: the concept filter stood on population and intervention alone so that the prevalence of proprioception assessment could be mapped without selection bias.

Supplementary searches (22 September 2026) addressed further platforms within access limits. Google Scholar was searched with targeted concept queries (supplementary tool, not a primary database — results are not reproducible record counts and were used to surface trials not found in PubMed). PEDro and Scopus have no openly accessible programmatic interface; they were covered by surrogate web sweeps targeted at PEDro- and Scopus-indexed records, and native platform exports remain planned through institutional access, together with Web of Science and CINAHL translations of the strategy. The Iranian Registry of Clinical Trials (IRCT) was searched to capture regional trials. One trial indexed in PubMed after the initial search date (identified via supplementary sweep and verified through E-utilities), and hand searching, completed the identification stage.

Selection of sources

Titles and abstracts of all records were screened against the eligibility criteria by one reviewer (author), with every exclusion assigned its primary reason code from the hierarchical framework; the complete record-level decision log, including one-line adjudication notes for every excluded record, is preserved in the accompanying screening decision workbook. All records added by supplementary searching were verified against a full-text or registry source before inclusion. Two published trials of thoracic manipulation without any exercise arm (Cross et al., 2011; Puentedura et al., 2011) were identified during sensitivity checking and excluded under code E4, confirming the framework's behaviour on known negative controls.

Data charting

Data were charted on a standardised form: first author, year, journal, study design, population and neck pain subtype, sample size, intervention (technique, dosage, supervision), comparator, outcome domains and instruments, and — wherever present — the method and time points of cervical proprioception (JPE) assessment. Where no proprioception outcome was reported, this absence was itself charted as a data point.

Synthesis

Results are presented as a numerical summary with PRISMA-ScR flow documentation, a characteristics table of included studies, a frequency map of outcome domains, and a qualitative narrative synthesis of intervention characteristics, in line with scoping review methodology [1, 16, 24]. No effect sizes were pooled, consistent with the mapping purpose of a scoping review.

RESULTS

Selection of sources of evidence

The searches identified 618 records: 377 from databases (371 PubMed-corpus records including one search-update record, plus 6 records added from supplementary Google Scholar, PEDro/Scopus-indexed surrogate sweeps), 1 from hand searching, and 240 from registries (ClinicalTrials.gov n=239; IRCT n=1). No duplicates were detected across sources. Title/abstract screening excluded 604 records, of which 27 were reviews and meta-analyses tagged for reference mining (code E7) and 577 were excluded for other reasons (E1 n=15; E2 n=14; E3 n=83; E4 n=81; E5 n=10; E6 n=114; E8 n=22; registry records not meeting the concept n=238). Fourteen sources

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(12 published reports of 11 trials and 2 registered trials) proceeded to full-text assessment, and all 14 were included. Figure 1 presents the PRISMA-ScR flow diagram; Table 1 summarises exclusion reasons.

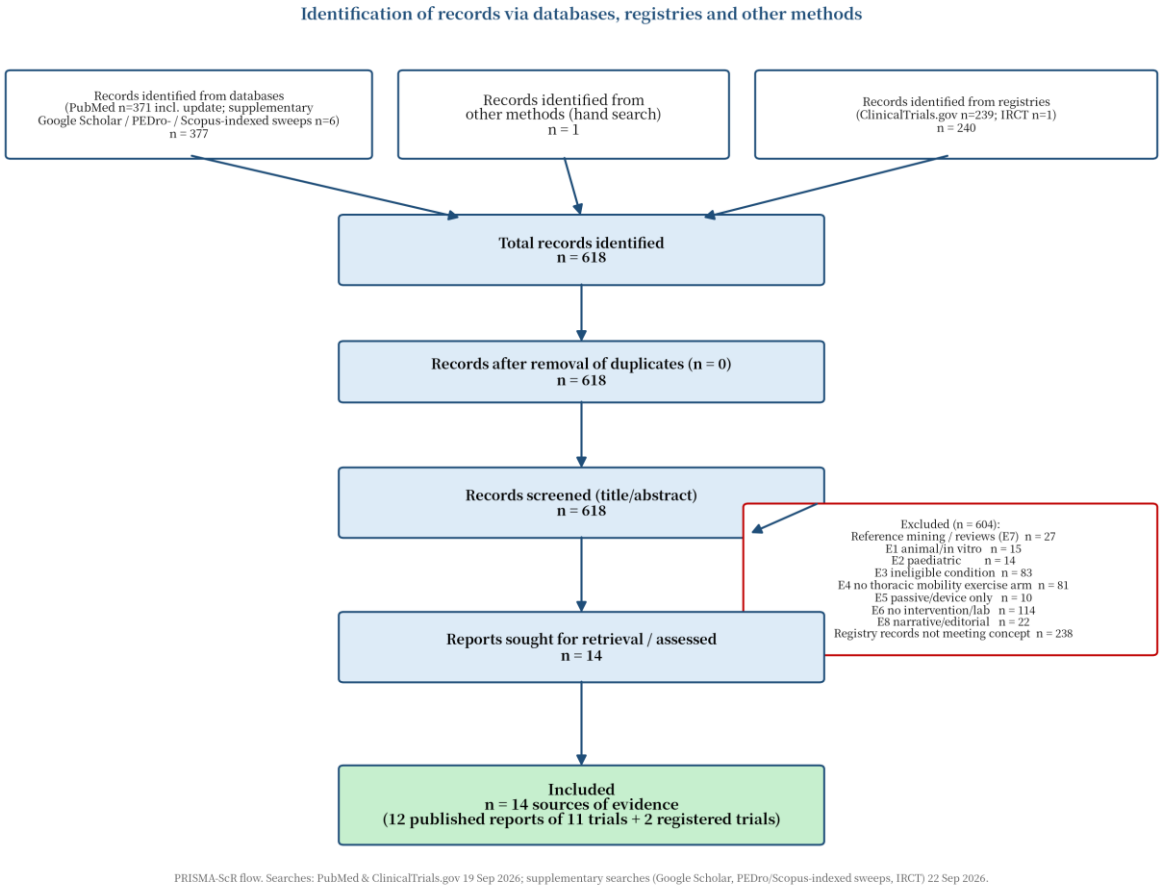


Figure 1. PRISMA-ScR flow diagram of record identification, screening and inclusion.

Table 1. Reasons for exclusion at title/abstract screening (hierarchical framework)

Code	Reason	n
E1	Animal or in vitro studies	15
E2	Paediatric or adolescent populations	14
E3	Ineligible condition (radiculopathy, myelopathy, inflammatory arthropathy, post-surgical, neoplastic, traumatic)	83
E4	No thoracic mobility/flexibility exercise arm (manipulation-only, mobilisation-only, or cervical-only-exercise trials)	81
E5	Passive or device-only interventions without exercise	10
E6	Laboratory/biomechanical or observational studies without an exercise intervention	114
E7	Reviews and meta-analyses (tagged for reference mining)	27
E8	Narrative reviews, editorials and clinical commentaries	22

E1–E8	Registry records not meeting concept criteria (of 240 registry records)	238

Characteristics of included studies

Table 2 charts the twelve published reports of eleven trials (428 participants; sample sizes 24–74) and the two registered trials. Ten were randomised controlled trials and one was a controlled trial with unclear allocation [7]. All evaluated a thoracic mobility, flexibility or self-mobilisation intervention — alone or combined with other exercise — against cervical exercise, thoracic manipulation, other exercise forms, or control conditions, between 2000 and 2026.

Table 2. Characteristics and outcome charting of included studies (n = 14 sources)

Study (source)	Design, population, n	Intervention (dosage)	Comparator	Outcome domains reported	JPE assessed?
Hanten et al., 2000; Phys Ther (PMID 11002435) [8]	Randomised 2-group trial; myofascial trigger points, neck/upper back; n=40	Home programme of ischaemic pressure + sustained stretching, 5 days	Active range-of-motion control	Pain (trigger point sensitivity), ROM	No
Cho, Lee & Lee, 2017; BMC Musculoskelet Disord (PMID 29233164) [4]	RCT; adults with forward head posture and neck pain; n=32	Upper thoracic mobilisation + mobility exercise, 4 weeks	Upper cervical mobilisation + stabilisation exercise	Posture (CVA), cervical ROM, pain (NPRS), pressure pain threshold, disability (NDI)	No
Nakamaru et al., 2019; J Bodyw Mov Ther (PMID 31103129) [14]	RCT; mechanical neck pain; n=52	Single-session thoracic spine self-mobilisation (immediate effects)	Control (no intervention/sham)	Pain, cervical ROM (immediate)	No
Corrective vs resistance exercise trial, 2021; Sci Rep (PMID 33589667) [7]	Controlled trial, allocation unclear; thoracic hyperkyphosis + chronic cervical pain; n=24	Corrective exercise or resistance exercise, 12 weeks	Physical therapy (passive modalities)	Posture (Cobb angle), cervical muscle strength, muscle cross-sectional area	No
Seo, Song & Shin, 2022; Med Sci Monit (PMID 35799408) [18]	RCT; office workers, chronic neck pain; n=26	Thoracic spine mobility exercise + cervical joint mobilisation + deep cervical flexor exercise, 6 weeks	Thoracic spine manipulation (same adjunct care)	Cervical ROM, pain	No
Tahir et al., 2022; Anaesth Pain Intensive Care	RCT; mechanical neck pain; n=36	Upper thoracic mobilisation +	Upper cervical mobilisation +	Pain (NPRS), cervical ROM, disability (NDI)	No

(doi:10.35975/apic.v26i4.1952) [23]	(supplementary search)	mobility exercise, 4 weeks	stabilisation exercise		
Sun et al., 2024; Sci Rep (PMID 38438448) [21]	RCT; chronic non-specific neck pain; n=30	Exercise (deep neck flexor + scapular training) + cervicothoracic self-mobilisation, 6 weeks	Exercise alone; exercise + cervical self-mobilisation	Pain, disability	No
Mahmoudabadi et al., 2024; J Gorgan Univ Med Sci (IRCT20220305054193N1) [12]	Single-blinded clinical trial; females 25–50 y, non-specific chronic neck pain; n=36 (supplementary search)	Neck stabilisation + thoracic mobility exercises, 8 weeks	Neck stabilisation alone; control	Disability, cervical ROM, muscle endurance	No (in this report)
Mahmoudabadi et al., 2024 (second report of IRCT20220305054193N1; bibliographic details pending) [11]	Same trial and sample (n=36); 8 weeks	Neck stabilisation + thoracic mobility exercises	Neck stabilisation alone; control	Pain, proprioception (laser pointer), posture (photography)	Yes — laser-based proprioception test
Cervical and thoracic Daoyin training trial, 2025; BMC Complement Med Ther (PMID 39905404) [6]	RCT; college students with upper crossed syndrome; n=74	Cervical and thoracic Daoyin training, 8 weeks	Control group (no Daoyin training)	Pain, posture, pulmonary function, cervical ROM, emotional state	No
Thoracic mobility added to cervical rehabilitation, 2026; J Back Musculoskelet Rehabil (PMID 42720569) [9]	RCT; chronic non-specific neck pain; n=54 (search-update record)	Thoracic mobility exercises added to cervical stabilisation exercises	Cervical stabilisation exercises alone	Pain, cervical muscle strength, disability, posture and spinal mobility (Spinal Mouse), upper-limb function	No
Kim & Park, 2026; Medicina (hand search; doi:10.3390/medicina62091666) [10]	RCT; chronic neck pain with forward head posture; n=24	Thoracic flexibility exercise, 4 weeks (3 days/week)	Cervical stabilisation exercise	Pain, cervical and thoracic ROM, spinal alignment (CVA, CRA, TKA), proprioception (laser JPE), disability (NDI)	Yes — laser-target JPE after active movements
Registered trial NCT05404646 (ClinicalTrials.gov; completed, results pending publication) [5]	RCT (registered); cervicogenic neck pain	Thoracic mobility exercise programme	Thoracic stretching exercise programme	Registered outcome set (pain, function, ROM)	Not stated in registration

Registered trial IRCT20220305054193N1 (Iranian Registry of Clinical Trials) [11]	Single-blinded RCT (registered); women 25–50 y, chronic neck pain, forward head posture	Neck stabilisation + thoracic mobility exercises, 8 weeks	Neck stabilisation alone; control	Registered outcome set: pain, ROM, muscle endurance, proprioception (laser), posture	Yes (registered outcome)

Intervention characteristics

Interventions spanned a wide dosage continuum: single-session thoracic self-mobilisation with immediate-outcome assessment [14]; 5-day home stretching programmes [8]; and 4-, 6-, 8- and 12-week supervised or mixed-supervision programmes [4, 18, 7, 6, 21, 23, 12, 9]. Frequency ranged from once daily to two or three sessions per week. Thoracic self-mobilisation was the most distinctive standalone technique [14, 21], while other studies embedded thoracic mobility work within multimodal rehabilitation (cervical joint mobilisation, deep cervical flexor training, scapular stabilisation) [4, 18, 21, 23, 9]. Comparators were predominantly other exercise forms aimed at the cervical region, reflecting the field's central clinical question: whether targeting the thoracic spine adds benefit beyond cervical-focused exercise.

Outcome domains

Figure 2 maps the outcome domains. Pain was most frequent (10/11 trials), followed by cervical ROM (9/11), posture and spinal alignment (6/11), disability/function (7/11), and single- or two-trial reporting of muscle strength, proprioception, pressure pain thresholds, pulmonary function, emotional state, muscle endurance and upper-limb function. Follow-up was uniformly short: the longest reported intervention was 12 weeks with assessments at completion; no trial reported long-term (>12-month) outcomes.

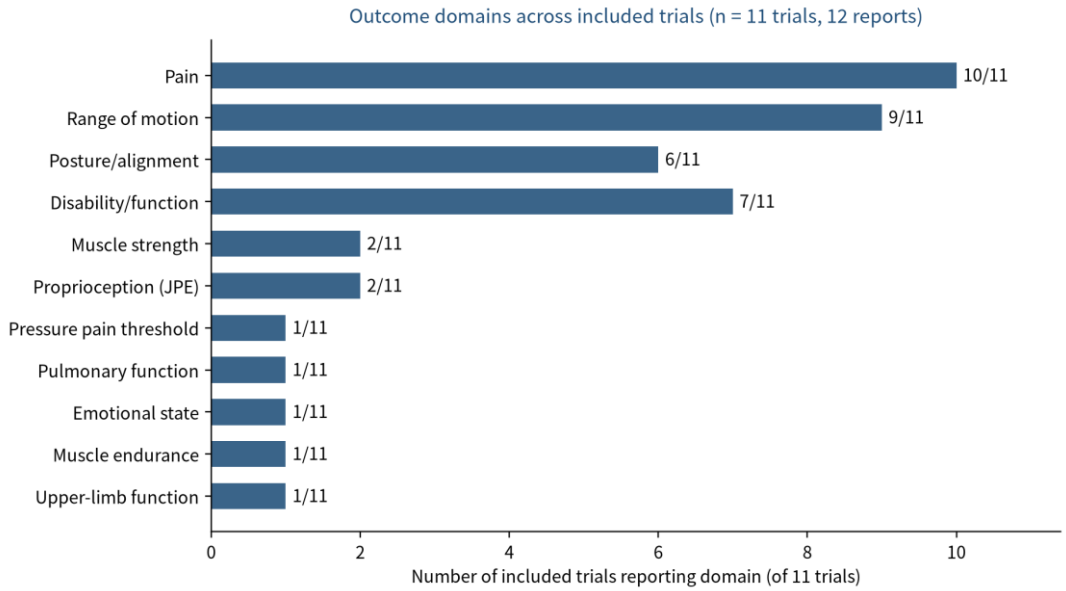


Figure 2. Frequency of outcome domains across the eleven included trials.

Cervical proprioception (JPE) mapping

Cervical proprioception was assessed in two of the eleven trials (2/11; 18%): the randomised trial by Kim and Park (2026) measured joint position error with a laser-target test after active cervical flexion, extension and rotation in adults with chronic neck pain and forward head posture, finding significantly greater improvement in the thoracic flexibility exercise group than in the cervical stabilisation exercise group after false-discovery-rate correction [10]; and the Iranian registered trial IRCT20220305054193N1 included neck proprioception (laser pointer) among its outcomes in women with chronic neck pain and forward head posture, reported in two

publications [12, 11]. All other included trials — including those reporting posture, alignment and ROM outcomes closely related to sensorimotor function — did not assess proprioception at any time point. Within the reference-mining pool, the sensorimotor training review by Zaidi et al. (2025) confirms that proprioception outcomes in neck pain rehabilitation are studied outside the thoracic-exercise literature [27], reinforcing that the gap mapped here is specific to thoracic mobility/flexibility exercise interventions.

Registered trials

Two completed registered trials were included: NCT05404646 comparing thoracic mobility exercise with thoracic stretching exercise in cervicogenic neck pain (results pending publication; no proprioception outcome stated in the registration) [5], and IRCT20220305054193N1, whose published reports are charted above [12, 11]. Their results, when published, will strengthen the evidence base; the IRCT trial's laser-based proprioception outcome makes it directly relevant to the JPE map.

DISCUSSION

This scoping review maps the active thoracic mobility and flexibility exercise literature in adults with neck pain and, for the first time, charts the extent of cervical proprioception assessment within it. Three findings stand out. First, the evidence base is small: twelve published reports of eleven trials totalling 428 participants met the concept criteria out of 618 records screened, confirming that the manipulation-centric emphasis of the existing review literature [13, 26, 3, 22] reflects the true distribution of research effort rather than an artifact of search strategy. Supplementary searching of Google Scholar, PEDro- and Scopus-indexed records, and the IRCT registry added four eligible trials that PubMed alone had not captured — several from non-MEDLINE-indexed journals — indicating that a PubMed-only review would have missed a meaningful share of this literature. Second, intervention characteristics are highly heterogeneous — dosages range from a single self-mobilisation session to 12-week multimodal programmes — which precludes any conclusion about dose–response and mirrors the heterogeneity noted in thoracic manipulation reviews [3]. Third, and central to the review's purpose, cervical proprioception is rarely measured: only two trials assessed it, both with laser-based tests consistent with the methodological literature [20, 17, 23].

The absence of proprioception outcomes matters for intervention development. Elevated JPE is a robust sensorimotor impairment in chronic neck pain [15], and proprioceptive training is an emerging rehabilitation strategy [27]. If thoracic mobility exercise improves cervical sensorimotor control — plausible given the biomechanical coupling of the regions [26, 19] and suggested by the two trials that measured it — this effect is currently invisible to most of the field because trials do not measure it. The outcome map (Figure 2) shows the literature clustered on pain, ROM and posture; disability, an outcome patients value, appears in seven of the eleven trials. Future trials should adopt a core outcome set spanning pain, function, ROM, and at least one validated sensorimotor measure such as laser-target JPE [17, 23].

For the present authors' programme of research, the map identifies both the design space (self-mobilisation to supervised multimodal programmes; 4–12 weeks; cervical exercise as the natural comparator) and the measurement gap (JPE) that a novel thoracic mobility intervention targeting cervical proprioception could fill.

Limitations

This review has limitations. Native searches of Scopus, Web of Science, CINAHL and PEDro were not possible without institutional access; these platforms were covered by documented surrogate web sweeps (PEDro- and Scopus-indexed records, Google Scholar, IRCT) rather than native platform exports, so some regionally published or non-indexed trials may remain unidentified, and the Google Scholar contribution is not reproducible as a record count. Language restriction (English) and the 2000-onward date range were feasibility choices documented per PRISMA-ScR. Screening was performed by a single reviewer with a preserved record-level decision log rather than independent dual screening, and conference abstracts with data were outside scope. One included Iranian trial is charted from its registration and two publications whose bibliographic details remain partially unconfirmed. Finally, because scoping reviews map rather than appraise, no risk-of-bias assessment was performed, and the reported improvements within studies should be interpreted accordingly.

CONCLUSION

Thoracic mobility and flexibility exercise interventions for adults with neck pain have been studied in a small, heterogeneous and short-term literature dominated by pain and ROM outcomes. Cervical proprioception (joint position error) has been assessed in just two of eleven trials. This map defines the evidence landscape on which a proprioception-targeted thoracic mobility intervention can now be developed and evaluated, with validated JPE measurement built in from the outset.

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