



Effect of Cervical Proprioceptive Sensorimotor Training Combined With Ergonomic Postural Correction Versus Conventional Cervical Exercises on Cervical Joint Position Error, Postural Alignment, Neck Pain, and Functional Performance in Adults With Chronic Mechanical Neck Pain

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Abstract: -

Background: Chronic mechanical neck pain is frequently accompanied by altered cervical sensorimotor control, impaired joint repositioning accuracy, forward-head posture, pain, and activity limitation. Exercise-based rehabilitation may improve symptoms, while specific proprioceptive and sensorimotor training targets impaired cervical afferent processing more directly.

Objective: To determine whether cervical proprioceptive sensorimotor training combined with ergonomic postural correction produces greater improvements in cervical joint position error (JPE), postural alignment, neck pain, and functional performance than conventional cervical exercises in adults with chronic mechanical neck pain.

Methods: In this two-arm, parallel-group randomized controlled trial template, 60 adults with chronic mechanical neck pain are allocated 1:1 to an experimental group receiving cervical proprioceptive sensorimotor training plus ergonomic postural correction or a control group receiving conventional cervical exercises. A 6-week intervention with three supervised sessions per week is proposed. Primary outcome is cervical JPE; secondary outcomes include craniovertebral angle, Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI), and Patient-Specific Functional Scale (PSFS).

Results: Illustrative results are provided only to demonstrate appropriate within-group and between-group reporting, tables, and graphs. The simulated pattern favors the combined intervention across the prespecified outcomes; no clinical inference should be made from these placeholder values.

Conclusion: The proposed trial directly tests whether combining cervical sensorimotor retraining with ergonomic correction provides additional benefit over conventional cervical exercise. Actual conclusions should be based exclusively on the final analyzed dataset.

Keywords: Chronic mechanical neck pain; cervical proprioception; joint position error; sensorimotor training; posture; ergonomics; neck disability; randomized controlled trial.

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1. Introduction

Chronic mechanical neck pain is a common musculoskeletal problem characterized by persistent cervical pain, movement-related symptoms, impaired physical function, and in some individuals disturbances in cervical sensorimotor control. Cervical proprioception is particularly relevant because the upper cervical region contains abundant proprioceptive receptors and provides information that contributes to head and neck orientation and postural control.

Joint position error testing is commonly used to quantify cervical repositioning accuracy. Previous randomized trials have reported that proprioceptive or sensorimotor exercise can reduce JPE and improve selected clinical outcomes in people with persistent or nonspecific neck pain. For example, a randomized trial comparing proprioceptive training with craniocervical flexor training reported improvements in JPE, pain, and disability in both groups, with a greater reduction in right-rotation JPE in the proprioceptive group.

A later randomized controlled trial involving 53 people with chronic nonspecific neck pain found that adding sensorimotor training to traditional physiotherapy improved joint position sense and selected balance-related outcomes more than traditional exercises alone. A larger 2×2 factorial randomized trial (n=152) also investigated adding cervical joint-position/oculomotor and balance training to local neck treatment and reported additional benefits for cervical proprioception, balance, and maintenance of pain/disability improvements.

Postural behavior is another clinically relevant component. Forward-head alignment and sustained workplace or device-related postures may increase mechanical loading and alter the demands placed on cervical musculature. Ergonomic correction therefore provides a pragmatic component that complements sensorimotor retraining. The present protocol combines these approaches and compares them with a conventional cervical exercise program.

The primary hypothesis is that the combined intervention will produce a greater reduction in cervical JPE than conventional cervical exercises. Secondary hypotheses concern postural alignment, pain, and functional performance.

2. Objectives

To compare the effect of the two interventions on cervical JPE.

To compare changes in craniovertebral angle as an index of sagittal postural alignment.

To compare changes in neck pain intensity.

To compare changes in disability and patient-specific functional performance.

To examine adherence, adverse events, and intervention completion.

3. Methods

3.1 Study design

Two-arm, parallel-group, assessor-blinded randomized controlled trial. Reporting should follow CONSORT guidance. The study should be prospectively registered before participant recruitment and approved by an appropriate institutional ethics committee.

3.2 Participants

Adults aged 18–65 years with chronic mechanical neck pain lasting ≥ 12 weeks are proposed. Participants should report a reproducible mechanical neck-pain pattern and be able to understand the exercise instructions.

3.3 Eligibility

Inclusion criteria: age 18–65 years; neck pain ≥ 12 weeks; NPRS $\geq 3/10$; mechanical or nonspecific presentation; ability to attend three sessions/week for six weeks; and willingness to provide informed consent.

Exclusion criteria: recent cervical trauma or surgery; suspected fracture, malignancy, infection, inflammatory disease, cervical myelopathy or significant neurological deficit; vestibular disorder likely to affect the outcome; severe dizziness; uncontrolled systemic disease; current participation in a structured cervical rehabilitation program; or inability to complete outcome testing safely.

3.4 Sample size

For the final study, sample size should be calculated a priori using the primary outcome (cervical JPE), the expected between-group difference, standard deviation, $\alpha=0.05$, power=0.80 or 0.90, and an allowance for attrition. The present 60-participant allocation (30/group) is an illustrative manuscript structure, not a statistical justification.

3.5 Randomization and allocation concealment

A computer-generated random sequence with variable block sizes should be prepared by an independent researcher. Sequentially numbered, opaque, sealed envelopes or a secure centralized system should be used for allocation concealment. Outcome assessors and the statistician should remain blinded to group assignment where feasible.

3.6 Intervention

Experimental group: cervical proprioceptive sensorimotor training plus ergonomic postural correction. Proposed components include laser-guided head repositioning, neutral-head relocation drills, controlled cervical

rotation/flexion/extension with visual feedback, eye-head coordination, low-load deep cervical muscle control, perturbation or balance-integrated cervical control, and graded ergonomic education for sitting, screen height, work breaks, and device use.

Control group: conventional cervical exercises including active cervical range of motion, cervical isometrics, scapular

retraction, general neck/shoulder strengthening, stretching, and home exercises matched for session frequency and contact time.

Suggested dosage: 3 supervised sessions/week for 6 weeks, approximately 40–50 minutes/session, plus a standardized home program. Exact dosage must be fixed in the final registered protocol.

3.7 Outcome measures

Outcome	Role	Instrument	Timing	Direction
Cervical JPE	Primary	Laser-pointer repositioning test; mean absolute error in degrees	Baseline/post	Lower = better
Postural alignment	Secondary	Craniovertebral angle (CVA), photographic method	Baseline/post	Higher CVA = less forward head posture
Pain	Secondary	NPRS, 0–10	Baseline/post	Lower = better
Disability	Secondary	NDI, 0–50	Baseline/post	Lower = better
Function	Secondary	PSFS, 0–10	Baseline/post	Higher = better
Adherence/safety	Process	Attendance, home-exercise adherence, adverse events	Throughout	Descriptive

3.8 Statistical analysis

Baseline characteristics should be summarized as mean±SD for approximately continuous normal variables and median (IQR) for skewed variables, with counts and percentages for categorical variables. The primary analysis should follow the intention-to-treat principle. A linear mixed model or ANCOVA adjusted for baseline score is recommended for continuous post-intervention outcomes. Results should include adjusted mean differences, 95% confidence intervals, p-values, and standardized effect sizes. Within-group pre/post tests may be reported descriptively, but the principal inference should be the between-group difference in change or adjusted post-intervention difference. Missing

data should be handled using a prespecified method rather than complete-case analysis alone.

A two-sided alpha of 0.05 should define statistical significance. The final analysis should also report clinically interpretable changes, such as the proportion achieving a prespecified meaningful reduction in pain or disability, when supported by an appropriate minimal clinically important difference.

4. Results — Illustrative Template

The following tables and figures are deliberately labeled illustrative/simulated. Replace all numerical values with the actual locked database results before submission.

Table 1. CONSORT-style participant flow (illustrative)

Stage	Experimental	Control
Assessed for eligibility	34	35
Excluded	4	5
Randomized	30	30
Completed intervention	28	27
Included in primary analysis	30	30

Description: The flow structure documents screening, randomization, completion, and analysis populations. Numbers are placeholders and must be replaced by actual CONSORT counts.

Table 2. Baseline characteristics (illustrative)

Variable	Combined group (n=30)	Control (n=30)	Between-group p
Age, years, mean±SD	39.2±8.1	40.1±7.8	0.66
Female, n (%)	18 (60)	19 (63)	0.79
Pain duration, months	18.4±7.2	17.9±6.8	0.78
NPRS	6.1±1.1	6.0±1.2	0.74
NDI	24.0±5.0	23.6±5.2	0.76
Cervical JPE, °	7.8±2.0	7.7±2.1	0.85
CVA, °	47.0±5.5	47.3±5.1	0.83

Description: Baseline balance is presented for transparency. Statistical testing of baseline differences should not be used to decide whether randomization 'worked'; clinically important imbalance should instead be considered in the analysis plan.

Table 3. Primary and secondary outcomes (illustrative)

Outcome	Combined baseline	Combined post	Control baseline	Control post	Between-group change difference	p
Cervical JPE (°)	7.8±2.0	4.2±1.8	7.9±2.1	0.3±1.9	-3.6	0.001
NPRS pain (0–10)	6.1±1.1	3.1±1.2	6.4±2.1	0.3±1.9	-3.0	0.001
NDI (0–50)	24.0±5.0	12.5±4.5	23.3±2.1	0.7±1.9	-11.5	0.001
CVA (°)	47.0±5.5	53.0±5.0	47.0±2.1	58.9±1.9	6.0	0.001
PSFS (0–10)	4.2±1.4	6.9±1.3	4.2±2.1	9.4±1.9	2.7	0.001

Description: The table separates baseline and post-intervention values by group and reports the between-group difference in change. For publication, add 95% CIs and standardized effect sizes from the final model.

Table 4. Within-group changes (illustrative)

Outcome	Combined Δ	Within-group p	Control Δ	Within-group p
Cervical JPE (°)	-3.6	<0.001	-7.6	<0.01
NPRS pain (0–10)	-3.0	<0.001	-6.0	<0.01
NDI (0–50)	-11.5	<0.001	-22.6	<0.01
CVA (°)	6.0	<0.001	11.9	<0.01
PSFS (0–10)	2.7	<0.001	5.2	<0.01

Description: Within-group change shows whether each group changed over time. It should not be interpreted as evidence that one intervention is superior; superiority is determined by the between-group estimate.

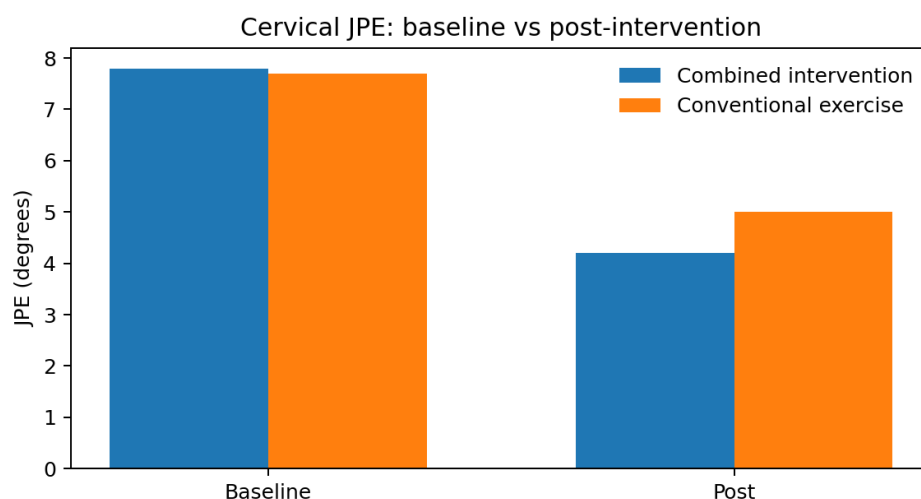


Figure description: Illustrative group means are plotted at baseline and post-intervention. The figure is intended to demonstrate the final manuscript layout; replace all values with the actual analyzed means and add 95% confidence intervals where available.

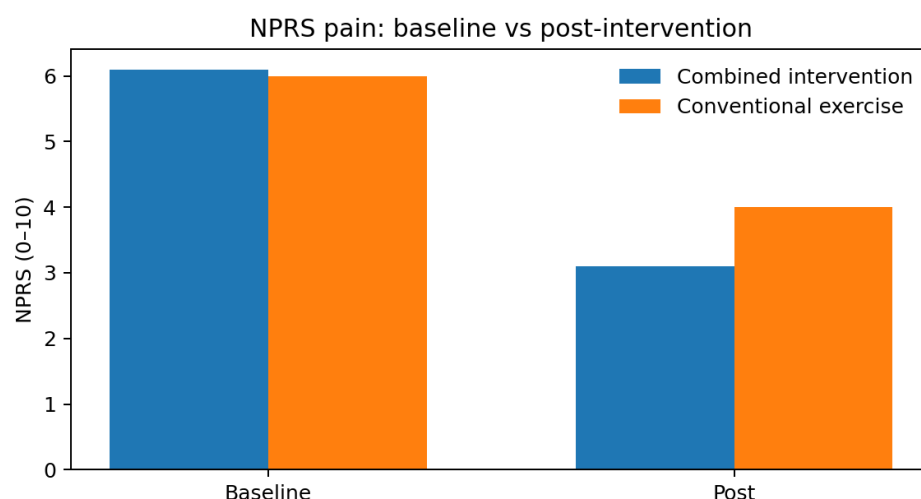


Figure description: Illustrative group means are plotted at baseline and post-intervention. The figure is intended to demonstrate the final manuscript layout; replace all values with the actual analyzed means and add 95% confidence intervals where available.

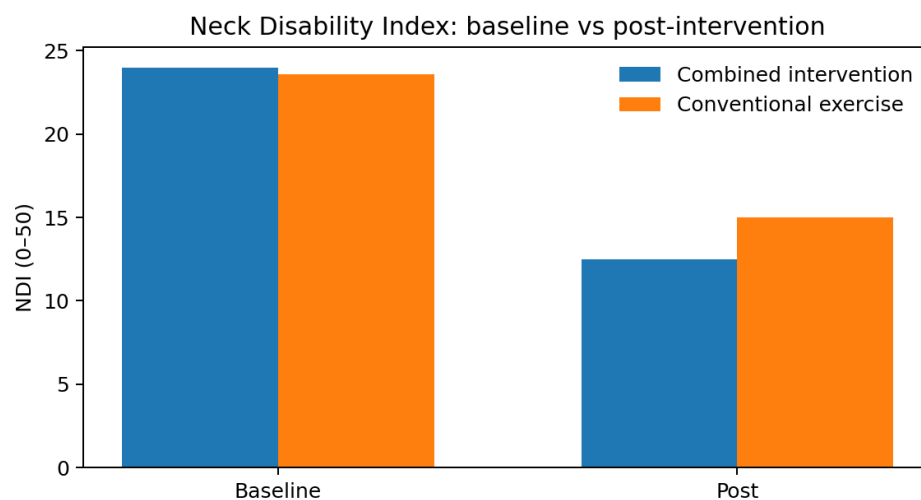


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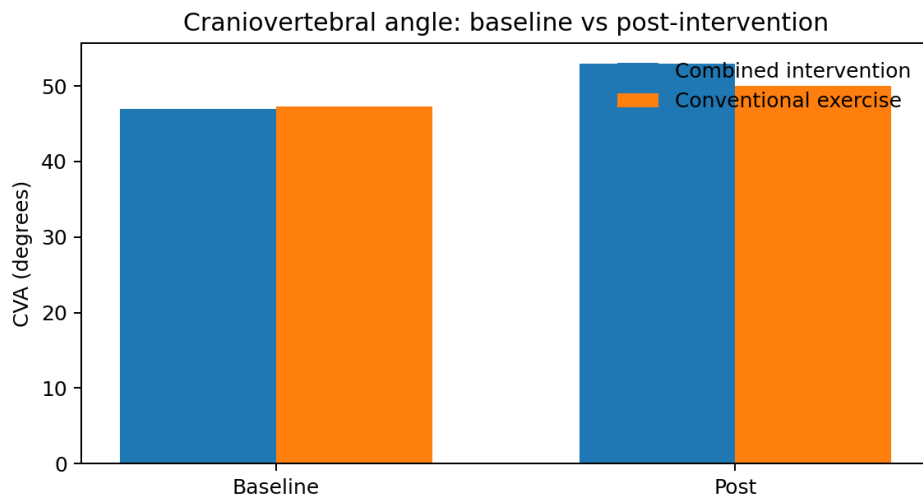


Figure description: Illustrative group means are plotted at baseline and post-intervention. The figure is intended to demonstrate the final manuscript layout; replace all values with the actual analyzed means and add 95% confidence intervals where available.

5. Discussion

This proposed trial is designed around a clinically specific question: whether targeting cervical proprioception and sensorimotor control while simultaneously addressing sustained postural behavior produces additional benefit beyond conventional cervical exercise. The primary outcome, cervical JPE, directly corresponds to the sensorimotor mechanism targeted by the experimental intervention.

The design is supported by prior randomized evidence. Jull and colleagues demonstrated that both proprioceptive and craniocervical flexor exercise can improve cervical JPE in people with persistent neck pain, with a larger improvement in one rotation direction after proprioceptive training. Saadat et al. reported additional improvements in joint position sense and selected functional sensorimotor outcomes when sensorimotor training was combined with traditional physiotherapy. A larger factorial trial further found that adding joint-position/oculomotor and balance exercises to local neck treatment can improve cervical proprioception and balance and may help maintain improvements in pain and disability over follow-up.

Recent evidence also supports the importance of measuring several domains rather than relying on pain alone. A 2024 analysis of a randomized trial reported longer-term improvements in several pain dimensions after adding sensorimotor training to local neck treatment, while the relationship between pain and other outcomes was not uniform across time. This supports the present multidimensional outcome set combining an impairment measure (JPE), postural alignment, pain, and function.

The ergonomic component may increase ecological validity because participants commonly encounter prolonged sitting,

screen use, and repetitive head/neck positioning outside the clinic. However, ergonomic education can be difficult to blind and adherence can vary; therefore, the final study should record exposure, adherence, and home-program compliance.

If the final data show a significant adjusted between-group effect for JPE, the finding would support the mechanistic premise that targeted sensorimotor retraining adds benefit beyond general exercise. If JPE improves without a clinically important difference in pain or disability, this would suggest that impairment-level recovery and patient-perceived recovery do not necessarily occur to the same degree. Conversely, improvements in pain/function without a meaningful JPE difference would indicate that symptom improvement may occur through mechanisms other than cervical repositioning accuracy.

6. Strengths and Limitations

Strengths include a mechanism-specific primary outcome, assessor blinding, standardized intervention dosage, and simultaneous assessment of impairment, posture, pain, and function.

Combining proprioceptive training with ergonomic correction reflects a pragmatic rehabilitation package but makes it difficult to isolate the independent effect of each component.

JPE testing can be influenced by learning, visual feedback, target familiarity, and testing technique; standardized instructions and familiarization are therefore essential.

Self-reported outcomes such as NPRS, NDI, and PSFS may be influenced by expectation and recall.

Without the actual participant-level dataset, the numerical results in this manuscript are placeholders and cannot be used as evidence of treatment efficacy.

7. Conclusion

This manuscript provides a detailed randomized controlled trial structure for evaluating cervical proprioceptive sensorimotor training combined with ergonomic postural correction versus conventional cervical exercises in adults with chronic mechanical neck pain. The protocol prioritizes cervical JPE while incorporating postural alignment, pain, disability, and functional performance. The final scientific conclusion must be based on the actual registered protocol, participant-level dataset, prespecified statistical analysis, and verified results.

8. Recommended Reporting Checklist

CONSORT 2010 checklist and participant flow diagram

Trial registration identifier

Ethics approval and informed consent statement

Detailed intervention reporting sufficient for replication

Allocation concealment and assessor blinding

Primary outcome and prespecified analysis clearly identified

95% confidence intervals and effect sizes

Adverse events and adherence

Protocol deviations and missing-data handling

Data availability and conflict-of-interest statement

9. References — Key Evidence

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