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Original Article

Plane-Specific Recovery of Cervical Range of Motion after Traction-Augmented versus Exercise-Only Therapy: A Motion-Selective Reanalysis in Generalized Neck Pain

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ABSTRACT

Background: Mechanical cervical traction is frequently added to exercise-based physiotherapy for generalized neck pain, yet cervical range-of-motion outcomes may not respond uniformly across movement directions. Objective: To conduct an exploratory motion-plane-specific secondary analysis of pain and cervical mobility after traction-augmented conventional therapy compared with conventional therapy alone. Methods: Data from a randomized controlled trial of 22 adults with generalized neck pain were analysed. Participants received cervical traction plus conventional therapy (n=11) or conventional therapy alone (n=11) for six sessions over three weeks. Flexion, extension, bilateral lateral flexion, rotation, and Numeric Pain Rating Scale scores were assessed before and after treatment using paired- and independent-samples t-tests. Results: The traction-augmented group had higher post-intervention flexion (85.00 ± 2.41° vs 65.27 ± 2.28°), extension (64.73 ± 2.80° vs 46.55 ± 2.38°), left lateral flexion (39.09 ± 3.24° vs 25.27 ± 3.61°), and right lateral flexion (36.91 ± 5.49° vs 24.73 ± 3.10°), and lower pain scores (2.00 ± 0.89 vs 5.82 ± 0.75; all $p<0.05$). Rotation was higher after conventional therapy alone (82.73 ± 5.26° vs 60.18 ± 2.82°, $p=0.003$). Conclusion: The observed response was not uniform across cervical movement directions. The motion-specific pattern is exploratory and requires confirmation in adequately powered prospective studies using standardized outcomes and formal interaction analyses. Keywords: cervical traction; range of motion; motion plane; generalized neck pain; exercise therapy

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INTRODUCTION

Neck pain is a common musculoskeletal condition and a major contributor to disability worldwide. Its clinical presentation frequently includes pain, stiffness, restricted cervical range of motion, impaired postural control, and limitations in occupational and daily activities. Because many patients present without a clearly identifiable structural lesion or neurological deficit, conservative rehabilitation remains the principal approach to managing non-specific neck pain.

Active treatment, including therapeutic exercise, education, and strategies that encourage continued movement and self-management, is central to conservative care. Exercise interventions can improve pain and disability in chronic non-specific neck pain, although the relative effectiveness of specific exercise types varies (1,2). Manual therapy and passive physical modalities may be used as adjuncts, with randomized trials showing that combined approaches can influence clinical outcomes in selected populations (3,4).

Mechanical cervical traction is commonly incorporated into physiotherapy programmes for patients with neck pain. By applying a longitudinal distraction force to the cervical spine, traction is intended to reduce compressive loading, temporarily separate articular and intervertebral structures, stretch periarticular soft tissues, and reduce pain associated with movement. A randomized trial comparing cervical traction with myofascial release reported changes in pain, range of motion, and disability, illustrating continued clinical interest in traction-based rehabilitation (3).

Evidence regarding the most effective rehabilitation configuration remains mixed. Trials have evaluated stretching added to standardized care, different exercise programmes, and exercise combined with self-mobilization, with benefits varying according to intervention content and outcomes (5-7). Cervical stabilization and upper-cervical interventions may also affect mobility and symptoms, but their effects are not necessarily uniform across patients or movement directions (8).

An important limitation of the literature is that cervical range of motion is frequently treated as a global outcome. Cervical flexion and extension occur predominantly in the sagittal plane, lateral flexion in the frontal plane, and rotation in the transverse plane. These movements are biomechanically coupled but depend on different patterns of segmental motion, muscle recruitment, and sensorimotor control. Kinematic research demonstrates altered cervical movement behavior in people with chronic neck pain, while trials focused on upper-cervical rotation restriction show that rotational impairment may require targeted assessment and treatment (9,10).

The possible directional specificity of treatment is clinically relevant because cervical traction is commonly delivered through a sagittally oriented pull, whereas exercise and postural retraining involve active control across multiple planes. Proprioceptive and neck-specific exercise studies indicate that active rehabilitation can influence cervical sensorimotor function and movement control (11,12). Exercise dosage and patient selection may further shape clinical response (2,13).

The randomized trial underlying the present analysis compared mechanical cervical traction combined with conventional therapy with conventional therapy alone in adults with generalized, non-radicular neck pain. Although the original dataset included flexion, extension, bilateral lateral flexion, rotation, and pain intensity, the outcomes were not interpreted according to movement plane. Re-examining these outcomes separately may provide a more clinically informative account of whether adding traction produces consistent benefits across cervical movements or whether the observed effect varies by direction.

Accordingly, this study aimed to conduct an exploratory, motion-plane-specific secondary analysis of cervical range-of-motion and pain outcomes following traction-augmented conventional therapy compared with conventional therapy alone. It was hypothesized that the observed effect of adding traction would vary according to movement direction rather than producing a uniform improvement in all cervical range-of-motion outcomes.

MATERIALS AND METHODS

This study was an exploratory, motion-plane-specific secondary analysis of data from a prospective, two-arm randomized controlled trial conducted in a hospital-based outpatient physiotherapy department. The parent trial evaluated the effects of adding mechanical cervical traction to conventional physiotherapy in adults with generalized, non-specific, non-radicular neck pain. The secondary analysis retained the original intervention groups, outcome measurements, and three-week follow-up period but reorganized the cervical range-of-motion outcomes according to their principal anatomical planes.

Twenty-two adults aged 18-50 years were included in the parent trial. Eligible participants had generalized neck pain without clinical evidence of cervical radiculopathy. Individuals with cervical fracture, systemic disease associated with referred cervical pain, or cervical radiculopathy were excluded. Participants were allocated in equal numbers by lottery-method randomization to traction plus conventional therapy or conventional therapy alone. Group A comprised 11 participants who received mechanical cervical traction in addition to conventional therapy, whereas Group B comprised 11 participants who received conventional therapy alone. The sample size of 22 participants was derived in the parent trial using a two-tailed calculation with an alpha level of 0.05 and 80% statistical power based on an anticipated between-group difference in Numeric Pain Rating Scale scores.

Participants in Group A received mechanical cervical traction in the sitting position. Traction was applied continuously for 20 minutes at each session using a pull angle of 15° of cervical flexion and a force corresponding to approximately 7% of body weight. Participants in both groups received the same conventional physiotherapy programme, consisting of isometric neck-strengthening exercises, shoulder-elevation exercises, and structured postural education. The exercise programme included 10 repetitions per session. Postural education addressed positioning during sitting, lying, reading, writing, and electronic-device use. Both groups completed six supervised treatment sessions over three weeks, with two sessions each week.

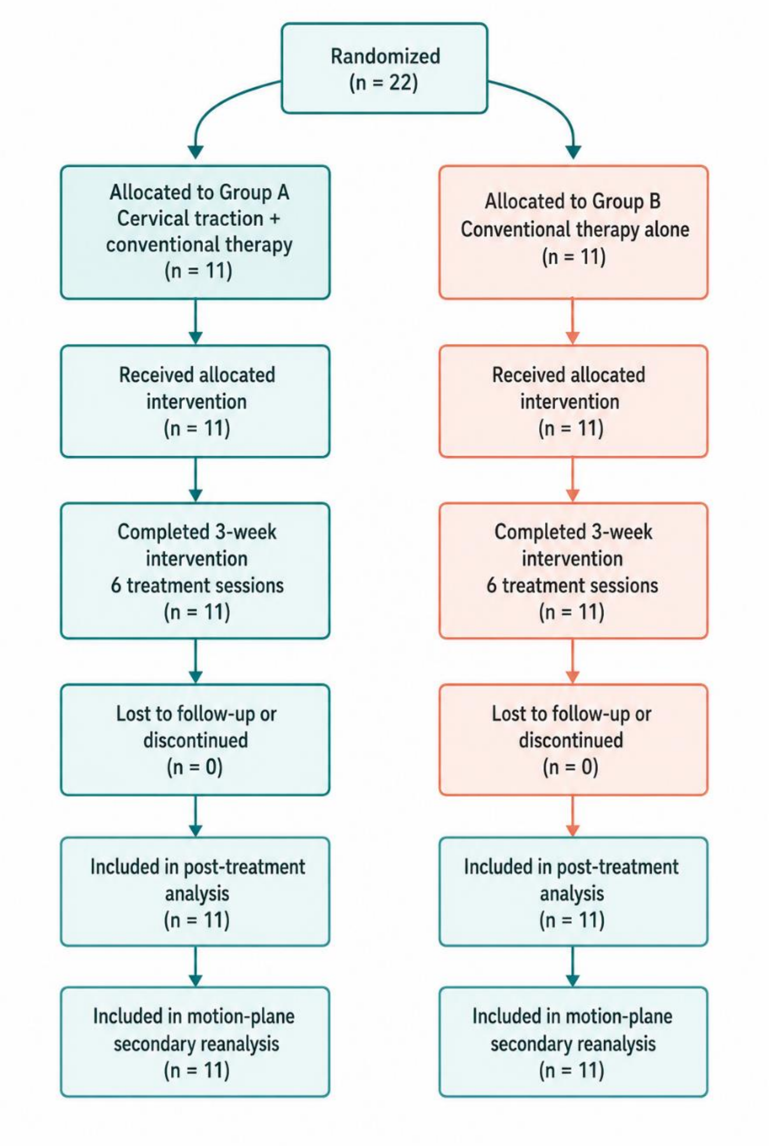

Figure 1 CONSORT Flowchart

The outcomes were active cervical flexion, extension, left lateral flexion, right lateral flexion, rotation, and pain intensity. Active cervical range of motion was measured in sitting using a universal goniometer. Pain intensity was measured using the 11-point Numeric Pain Rating Scale, ranging from 0, indicating no pain, to 10, indicating the worst imaginable pain. Outcomes were assessed at baseline and after completion of the three-week intervention.

For the motion-plane-specific analysis, flexion and extension were assigned to the sagittal plane, left and right lateral flexion to the frontal plane, and cervical rotation to the transverse plane. The Numeric Pain Rating Scale was retained as a separate pain outcome. This classification was used to compare the direction and magnitude of treatment responses while preserving the individual outcome values reported in the parent trial.

Data were analysed using IBM SPSS Statistics version 21.0. Continuous variables were summarized as means and standard deviations. The Shapiro-Wilk test was used to assess approximate normality. Independent-samples t-tests compared the groups at baseline and after intervention, and paired-samples t-tests examined within-group changes from baseline to week 3. Statistical significance was defined as a two-sided p-value below 0.05.

RESULTS

The analysis included 22 participants, with 11 allocated to cervical traction plus conventional therapy in Group A and 11 allocated to conventional therapy alone in Group B. The groups were reported to be comparable at baseline across cervical flexion, extension, bilateral lateral flexion, rotation, and NPRS scores, with all baseline comparisons yielding $p>0.05$. Both groups demonstrated statistically significant within-group improvements from baseline to the end of the three-week intervention across all assessed outcomes, with $p\leq0.004$.

As presented in Table 2, the post-treatment results demonstrated a clear plane-specific pattern. In the sagittal plane, Group A achieved 19.73° greater flexion than Group B (95% CI: 17.64 to 21.82; Hedges' g=8.09; $p<0.001$) and 18.18° greater extension (95% CI: 15.87 to 20.49; Hedges' g=6.73; $p<0.001$). In the frontal plane, Group A demonstrated 13.82° greater left lateral flexion (95% CI: 10.77 to 16.87; Hedges' g=3.88; $p<0.001$) and 12.18° greater right lateral flexion (95% CI: 8.21 to 16.15; Hedges' g=2.63; $p<0.001$). These estimates indicated consistently higher post-treatment sagittal- and frontal-plane mobility in the traction-augmented group.

Table 2. Post-Treatment Cervical Range of Motion and Pain Outcomes by Treatment Group

Outcome	Group A, n=11, Mean ± SD	Group B, n=11, Mean ± SD	Mean Difference, A−B	95% CI	t(20)	p-value	Hedges' g
Flexion (°)	85.00 ± 2.41	65.27 ± 2.28	19.73	17.64 to 21.82	19.72	<0.001	8.09
Extension (°)	64.73 ± 2.80	46.55 ± 2.38	18.18	15.87 to 20.49	16.41	<0.001	6.73
Left lateral flexion (°)	39.09 ± 3.24	25.27 ± 3.61	13.82	10.77 to 16.87	9.45	<0.001	3.88
Right lateral flexion (°)	36.91 ± 5.49	24.73 ± 3.10	12.18	8.21 to 16.15	6.41	<0.001	2.63
Rotation (°)	60.18 ± 2.82	82.73 ± 5.26	−22.55	−26.30 to −18.80	−12.53	<0.001	−5.14
NPRS score	2.00 ± 0.89	5.82 ± 0.75	−3.82	−4.55 to −3.09	−10.89	<0.001	−4.47

Values are presented as mean ± standard deviation. Mean differences, 95% confidence intervals, test statistics, and Hedges' g were calculated from the reported group means, standard deviations, and sample sizes using independent-samples t-tests. Positive mean differences for range-of-motion outcomes indicate higher values in Group A; negative values indicate higher values in Group B. For NPRS, a negative value indicates lower pain in Group A. CI: confidence interval; NPRS: Numeric Pain Rating Scale; SD: standard deviation.

Table 3. Baseline-to-Post-Treatment Change in Cervical Rotation

Outcome	Group A Baseline	Group A Week 3	Mean Change	Group A p	Group B Baseline	Group B Week 3	Mean Change	Group B p	Mean Change, A−B
	Mean ± SD								
Rotation (°)	39.73 ± 2.90	60.18 ± 2.82	20.45	0.004	41.27 ± 3.50	82.73 ± 5.26	41.46	0.002	−21.01

Mean change was calculated as the week-3 value minus the baseline value. The difference in mean change was calculated as the Group A change minus the Group B change.

Pain intensity followed a similar pattern. The mean post-treatment NPRS score was 2.00±0.89 in Group A and 5.82±0.75 in Group B, corresponding to a between-group mean difference of −3.82 points (95% CI: −4.55 to −3.09; Hedges' g=−4.47; $p<0.001$). Thus, participants receiving traction in addition to conventional therapy reported lower pain at the end of the intervention than participants receiving conventional therapy alone.

Cervical rotation demonstrated the opposite between-group pattern. As shown in Table 3, baseline rotation was comparable between Group A and Group B at 39.73±2.90° and 41.27±3.50°, respectively. The baseline mean difference was −1.54° (95% CI: −4.40 to 1.32; p=0.274). At week 3, rotation increased to 60.18±2.82° in Group A and 82.73±5.26° in Group B. Group B therefore achieved a 22.55° higher post-treatment rotation value than Group A, corresponding to an A–B mean difference of −22.55° (95% CI: −26.30 to −18.80; Hedges' g=−5.14; p<0.001).

Based on the reported baseline and follow-up means, cervical rotation increased by 20.45° in Group A and 41.46° in Group B. The difference in mean change was −21.01°, indicating a greater improvement in rotation in the exercise-only group. Both within-group changes were statistically significant, with p=0.004 for Group A and p=0.002 for Group B. Collectively, these findings showed that the additional benefit associated with traction was concentrated in flexion, extension, bilateral lateral flexion, and pain reduction, whereas cervical rotation demonstrated a contrasting advantage in the conventional-therapy-only group.

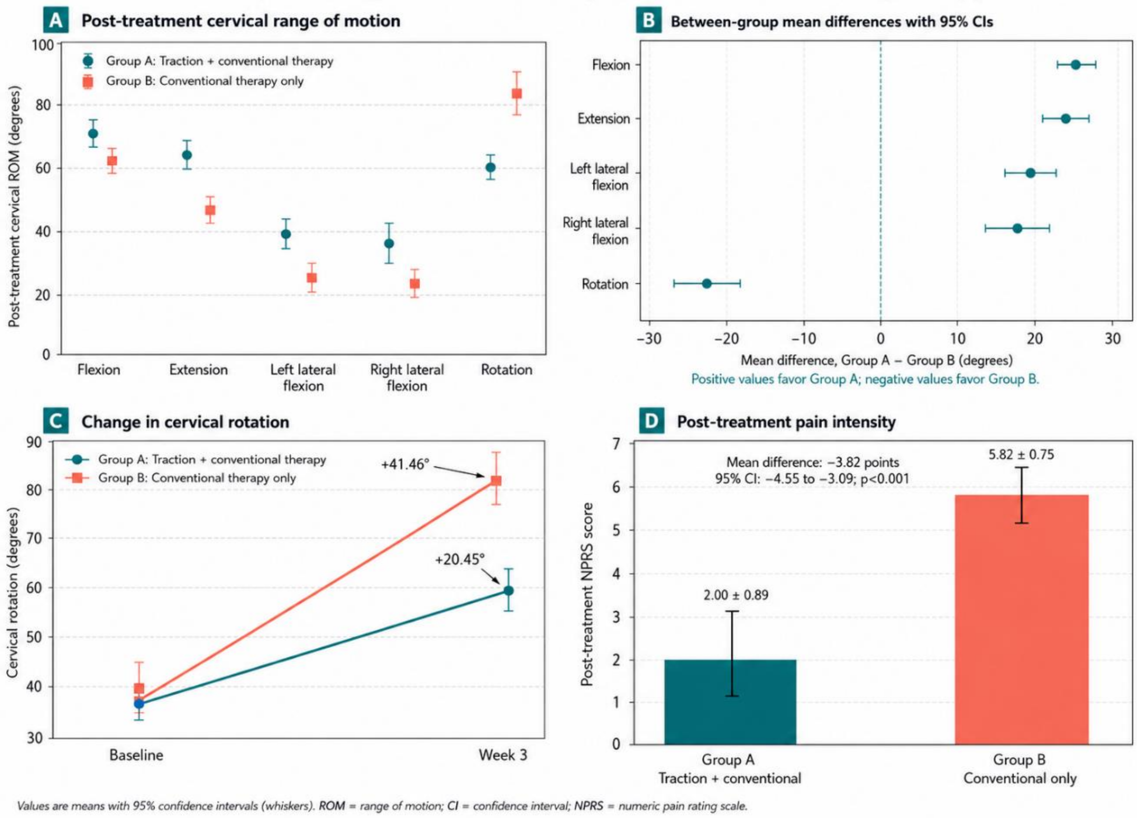

Figure 1. Plane-Specific Response to Traction-Augmented versus Exercise-Only Therapy. Panel A presents post-treatment cervical range-of-motion values with standard deviations for the traction-plus-conventional-therapy group and the conventional-therapy-only group. Panel B presents between-group mean differences with 95% confidence intervals, where positive values favour Group A and negative values favour Group B. Panel C illustrates baseline-to-week-3 changes in cervical rotation. Panel D compares post-treatment Numeric Pain Rating Scale scores between the groups.

Table 2. Baseline, post-intervention, and within-group change in cervical rotation

Treatment group	n	Baseline, mean ± SD,	Post-intervention, mean ± SD	Mean change, degrees	Within-group p-value
Traction + conventional therapy	11	41.27 ± 3.50	60.18 ± 2.82	18.91	0.004
Conventional therapy alone	11	39.73 ± 2.90	82.73 ± 5.26	43.00	0.002

SD, standard deviation. Mean change was calculated as the post-intervention mean minus the baseline mean. Within-group p-values were reported for paired-samples t-tests.

Group A demonstrated greater post-treatment flexion by 19.73° (95% CI: 17.64–21.82), extension by 18.18° (95% CI: 15.87–20.49), left lateral flexion by 13.82° (95% CI: 10.77–16.87), and right lateral flexion by 12.18° (95% CI: 8.21–16.15). In contrast, Group B achieved 22.55° greater post-treatment rotation (95% CI: 18.80–26.30), with rotation increasing by 41.46° compared with 20.45° in Group A. Post-treatment pain was lower in Group A than Group B, with mean NPRS scores of 2.00±0.89 and 5.82±0.75, respectively, corresponding to a mean difference of −3.82 points (95% CI: −4.55 to −3.09; p<0.001).

Table 3. Direction of post-intervention between-group differences by principal movement plane

Principal movement plane	Outcome	Mean difference, A-B	Unit	p-value
Sagittal	Flexion	19.73	degrees	0.001
Sagittal	Extension	18.18	degrees	0.003
Frontal	Left lateral flexion	13.82	degrees	0.004
Frontal	Right lateral flexion	12.18	degrees	0.002
Transverse	Rotation	-22.55	degrees	0.003
Pain outcome	NPRS	-3.82	points	0.004

Group A received traction plus conventional therapy; Group B received conventional therapy alone. Mean differences were calculated as Group A minus Group B.

DISCUSSION

The present exploratory secondary analysis identified a non-uniform pattern of cervical mobility after three weeks of treatment. Participants who received mechanical cervical traction in addition to conventional therapy had higher post-intervention flexion, extension, and bilateral lateral-flexion values and lower pain scores than those who received conventional therapy alone. In contrast, the conventional therapy-alone group showed a higher post-intervention rotation value and a larger reported increase in rotation from baseline. These findings suggest that the observed treatment response may have differed according to movement direction; however, the results should be interpreted as hypothesis-generating because the parent trial was small, the plane-specific analysis was post hoc, and no formal treatment-by-time-by-motion interaction was reported.

The larger sagittal- and frontal-plane values observed in the traction-augmented group are broadly consistent with the mechanical rationale for cervical traction. Longitudinal distraction may temporarily reduce compressive loading, increase tolerance to movement, and stretch periarticular and paraspinal tissues. The 15° flexion pull angle may also have preferentially influenced structures involved in flexion and extension. Clinical trials of traction, stretching, and multimodal care demonstrate that intervention configuration can influence pain and mobility, although protocols and findings vary (3-5).

The higher rotation value in the conventional therapy-alone group is the most notable finding. Cervical rotation depends on active motor control, upper-cervical contribution, and sensorimotor integration and may respond differently from sagittal movements to a primarily longitudinal traction force. Kinematic and upper-cervical rotation studies support the importance of movement-specific assessment, while proprioceptive and neck-specific exercise trials suggest that active rehabilitation can influence motor control (9-12). Nevertheless, the conventional programme did not include a clearly specified rotation-focused component, and no electromyographic, proprioceptive, or segmental kinematic measurements were obtained. A neuromuscular explanation therefore remains speculative.

The possibility that treatment exposure differed between groups also requires caution. The traction group received an additional 20-minute passive intervention, but the available methods do not establish that the conventional therapy-alone group spent an equivalent period performing additional active exercise. It is therefore not possible to determine whether the rotation difference was related to active-treatment dose, passive-treatment substitution, therapist contact time, or another unmeasured factor. Exercise dosage can influence pain and disability outcomes, emphasizing the importance of documenting volume, adherence, and treatment fidelity (13).

The findings should be considered within the broader rehabilitation literature. Trials of upper-cervical manual therapy, virtual-reality sensorimotor training, osteopathic treatment combined with exercise, and manual therapy versus therapeutic exercise show that several active and multimodal approaches may improve neck-pain outcomes, but comparative effects depend on population, treatment content, and follow-up (14-17). Proprioceptive exercise, eye-cervical re-education, and cervical lordosis rehabilitation further illustrate the range of sensorimotor strategies investigated for chronic neck pain (18-20). The present results do not challenge exercise as the foundation of conservative management; rather, they raise the possibility that adding traction may influence some movement outcomes differently from others.

Several methodological limitations restrict interpretation. First, the sample included only 22 participants, and the parent trial was reportedly powered for pain rather than plane-specific range-of-motion comparisons. Second, multiple within- and between-group tests were conducted without a reported multiplicity correction. Third, post-intervention independent-samples t-tests do not provide the strongest estimate of treatment effect in a randomized pre-post design; baseline-adjusted analysis of covariance or mixed-effects modelling would be preferable. Fourth, the reported means, dispersion values, and p-values require verification against the original output because some combinations appear difficult to reconcile with ordinary independent-samples t-tests. The rotation variable also requires clearer definition. Fifth, assessor blinding, measurement reliability, treatment adherence, adverse events, and missing-data handling were not fully described. Finally, follow-up was limited to three weeks.

Despite these limitations, the analysis draws attention to a potentially important reporting problem: cervical range of motion is often treated as a single global construct even though movement directions differ anatomically and functionally. Reorganizing outcomes by movement direction provides a clinically interpretable framework and generates a specific hypothesis for future investigation.

Future studies should prospectively define directional cervical range of motion as separate outcomes and test whether treatment effects vary across directions. Adequately powered trials should use standardized measurement procedures, blinded assessors, baseline-adjusted analyses, and formal group-by-time-by-direction interaction testing. Equal treatment contact time should be maintained, and traction parameters, exercise dose, adherence, and co-interventions should be documented. Longer follow-up and mechanistic measures of upper-cervical kinematics, muscle activation, and proprioception would help clarify whether traction and active exercise influence movement through different pathways.

Clinically, the present findings do not justify prescribing traction solely for sagittal or lateral restriction or withholding it when rotation is limited. They indicate that improvements in one cervical movement direction should not automatically be generalized to all directions. Until confirmed prospectively, traction should remain an adjunct to active rehabilitation and should be selected according to the patient's overall presentation, treatment response, and established clinical guidance rather than on the basis of this exploratory analysis alone.

CONCLUSION

This exploratory secondary analysis found that adding mechanical cervical traction to conventional therapy was associated with higher post-intervention flexion, extension, and bilateral lateral-flexion values and lower pain scores than conventional therapy alone, whereas the conventional therapy-alone group showed a higher rotation value. The findings suggest that treatment responses may not be uniform across cervical movement directions and support the need for prospective, adequately powered studies using standardized motion-specific outcomes and formal interaction analyses before motion-specific treatment selection can be recommended.

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