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*Original Article*

# Effectiveness of Pilates Exercises With Breathing Re-Education on Pain, Endurance, Sleep Disturbance, and Neck Disability in Working Women With Chronic Non-Specific Neck Pain

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## ABSTRACT

Background: Chronic non-specific neck pain is highly prevalent among working women and is commonly associated with pain, reduced cervical endurance, sleep disturbance, and functional disability. Exercise-based rehabilitation is widely used, and Pilates has shown potential benefit, but the added value of breathing re-education remains insufficiently defined. Objective: To evaluate the effectiveness of Pilates exercises combined with breathing re-education on pain intensity, deep cervical flexor endurance, sleep disturbance, and neck-related disability in working women with chronic non-specific neck pain. Methods: A parallel-group randomized controlled trial was conducted at Ghurki Trust Teaching Hospital, Lahore, from June 2024 to January 2025. Fifty-six participants were randomized, and 52 completed the study. Participants were allocated to either Pilates plus breathing re-education or Pilates alone for 6 weeks, with supervised sessions conducted three times weekly. Outcomes included Numeric Pain Rating Scale, Craniocervical Flexion Test, Insomnia Severity Index, and Neck Disability Index-Urdu, assessed at baseline, week 3, and week 6. Results: The combined intervention demonstrated greater improvement than Pilates alone across all outcomes by week 6. Pain decreased from 5.58±0.50 to 3.03±0.45 versus 5.42±0.70 to 4.15±0.61, endurance increased from 18.42±1.27 to 22.46±1.17 mmHg versus 18.35±1.09 to 19.38±1.06 mmHg, ISI decreased from 17.38±3.51 to 11.65±3.19 versus 18.73±2.63 to 16.38±2.45, and NDI decreased from 24.73±5.35 to 13.46±5.51 versus 24.08±4.76 to 20.65±4.54. Significant between-group and time effects were reported for major endpoints. Conclusion: Pilates combined with breathing re-education was more effective than Pilates alone in improving pain, endurance, sleep disturbance, and disability over six weeks in working women with chronic non-specific neck pain. Keywords: chronic neck pain, Pilates, breathing re-education, sleep disturbance, disability, endurance, working women.

## INTRODUCTION

Chronic non-specific neck pain is one of the most prevalent musculoskeletal disorders worldwide and is associated with substantial pain, functional limitation, reduced work performance, and increased healthcare burden. It commonly affects the posterior cervical region and adjacent shoulder girdle structures without a clearly identifiable pathological cause, and when symptoms persist beyond three months, the condition is generally considered chronic. Contemporary evidence suggests that chronic non-specific neck pain is not merely a local pain disorder but a multidimensional condition involving

biomechanical dysfunction, altered sensorimotor control, muscular imbalance, reduced endurance, and psychosocial contributors, all of which may perpetuate symptoms and disability (1-6). The cervical spine has a specialized role in supporting head movement, postural control, and respiratory assistance, and disturbances in cervical muscle coordination may therefore affect both mechanical efficiency and broader functional performance (7-10).

A recurring clinical feature in chronic neck pain is impaired activation of the deep cervical flexors with compensatory overactivity of superficial cervical musculature, particularly the sternocleidomastoid and anterior scalene muscles. These changes contribute to deficient cervical stabilization, postural abnormalities, and increased symptom persistence. In parallel, chronic neck pain has also been linked with impaired proprioception, disturbed motor control, and reduced muscular endurance, each of which can compromise daily functioning and occupational tolerance (4,11-13). Epidemiological evidence further indicates that neck pain is especially common among women, with risk amplified by prolonged sitting, repetitive work tasks, suboptimal workstation ergonomics, psychosocial stress, poor sleep, and low physical activity levels. Female workers are particularly vulnerable because occupational and domestic demands often coexist, increasing cumulative biomechanical and psychological load (14-20).

In working women, chronic neck pain frequently presents alongside forward head posture, sustained muscle tension, fatigue, sleep disturbance, and reduced functional capacity. This pattern is clinically relevant because sleep impairment and pain appear to reinforce one another in a bidirectional manner, such that poor sleep increases pain sensitivity and persistent pain further disrupts restorative sleep. Over time, this cycle may worsen disability, reduce work efficiency, and impair quality of life (18-20). Emerging evidence also suggests that forward head posture and chronic cervical dysfunction may adversely influence respiratory mechanics, pulmonary efficiency, and respiratory muscle performance. These interrelationships have increased interest in interventions that not only target pain and neck disability but also address posture, endurance, and breathing behavior as part of an integrated rehabilitation strategy (21-23).

Conservative management remains the preferred first-line approach for chronic non-specific neck pain and commonly includes therapeutic exercise, manual therapy, physical modalities, and psychologically informed care. Among exercise-based interventions, Pilates has received increasing attention because it emphasizes postural alignment, trunk and cervical control, flexibility, neuromuscular coordination, and movement precision. Systematic reviews suggest that Pilates may improve pain and disability in musculoskeletal conditions, including neck pain, particularly when programs are structured and supervised. Its therapeutic rationale lies in restoring muscular balance, enhancing segmental stability, and improving movement efficiency, all of which are pertinent to chronic cervical dysfunction (24-32). However, although Pilates appears promising, the relative contribution of breathing-focused retraining alongside Pilates remains insufficiently defined.

Breathing re-education may offer additional benefit because dysfunctional breathing patterns are often observed in individuals with chronic neck pain, especially in the presence of postural disturbance and accessory muscle overuse. Techniques such as diaphragmatic breathing may reduce unnecessary cervical muscle recruitment, improve relaxation, optimize oxygenation, and modulate autonomic balance, thereby potentially influencing pain, endurance, sleep, and disability simultaneously. Despite this plausible multidimensional benefit, there remains limited randomized clinical evidence evaluating whether the addition of breathing re-education to a structured Pilates program produces superior outcomes compared with Pilates alone in working women with chronic non-specific neck pain. Addressing this gap is clinically important because this population experiences persistent symptom burden with meaningful implications for occupational health and day-to-day function. Therefore, this study aimed to evaluate the effectiveness of Pilates exercises combined with breathing re-education on pain intensity, deep cervical flexor endurance, sleep disturbance, and neck-related disability in working

women with chronic non-specific neck pain, with the hypothesis that the combined intervention would yield greater improvement than Pilates training alone (29-32).

## MATERIALS AND METHODS

This study was designed as a parallel-group, assessor-blinded randomized controlled trial conducted at Ghurki Trust Teaching Hospital, Lahore, Pakistan, between June 2024 and January 2025. The trial was planned to compare the effects of Pilates exercises combined with breathing re-education against Pilates-based exercise alone in working women with chronic non-specific neck pain. The protocol followed a prospective experimental design with repeated outcome assessment at baseline, week 3, and week 6, allowing evaluation of both short-term change and between-group differences over time. The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Faculty of Rehabilitation Sciences, Lahore University of Biological and Applied Sciences under reference ERC/FORS/24/10. The trial was prospectively registered in the Iranian Registry of Clinical Trials before participant enrollment began (33-35).

A priori sample size estimation was based on previously reported differences in related intervention outcomes, using expected mean values of 4.16 in one group and 9.76 in the comparison group, with standard deviations of 3.82 and 6.93, respectively. Assuming a 95% confidence level and 80% statistical power, the minimum required sample was calculated as 52 participants. To reduce the risk of attrition-related loss of power, 56 eligible participants were ultimately enrolled and randomized, and 52 completed the trial and were included in the final analysis, with 26 participants retained per group. This approach maintained the target analytical sample while preserving allocation balance at study completion (33). Women aged 25 to 50 years with chronic non-specific neck pain of more than three months' duration were screened for eligibility. Participants were required to be engaged in white-collar occupations with routine work demands of approximately 6 to 8 hours daily, reflecting the occupational profile most relevant to the study question. Participants were excluded if they had cervical radiculopathy, rheumatological disease, a history of cervical trauma including whiplash-associated injury, neurological disorders such as stroke, Parkinson's disease, or multiple sclerosis, tumors, pregnancy, or respiratory conditions including asthma and chronic obstructive pulmonary disease. These criteria were selected to minimize diagnostic heterogeneity and reduce confounding from conditions likely to independently influence pain, respiratory performance, or functional disability (34-43).

*Figure 1 Participant positioned supine during the supervised intervention session, demonstrating an exercise component of the study protocol.*

Potential participants were assessed in the physiotherapy department using a standardized screening procedure. Eligible women were informed about the purpose, procedures, benefits, and possible inconveniences of participation, and written informed consent was obtained before randomization. After consent and baseline assessment, participants were randomly allocated in a 1:1 ratio to either the combined intervention group or the Pilates-only group. Randomization was performed using a computer-generated block randomization sequence with variable block sizes of 4, 6, and 8 to preserve

allocation concealment and reduce predictability. The sequence was implemented using sequentially numbered, opaque, sealed envelopes prepared by an independent researcher who was not involved in participant recruitment, treatment delivery, or outcome assessment. Outcome assessment was performed by a blinded assessor to reduce measurement bias, whereas intervention delivery was undertaken by a physiotherapist who was aware of treatment assignment due to the nature of the exercise protocols (33).

The intervention period lasted 6 weeks, with supervised treatment sessions conducted 3 times per week. Each session was standardized to 55 minutes. Both groups received a 5-minute warm-up followed by Pilates-based cervical and postural exercise training and a 5-minute cool-down. The Pilates-only group completed 45 minutes of Pilates and neck isometric exercises after warm-up, whereas the combined intervention group completed 30 minutes of Pilates and neck isometric exercises followed by 15 minutes of breathing re-education. Exercise intensity and progression were individualized according to participant tolerance and physical capacity, but the structure remained consistent across sessions. The exercise program included cervical spine retraction, neck rolls, head nodding, dynamic neck flexion and extension, swan dive preparation, and neck isometric exercises intended to improve cervical muscle control, postural alignment, and muscular endurance. Breathing re-education emphasized diaphragmatic breathing and slow controlled respiratory practice intended to decrease accessory muscle overuse, facilitate relaxation, and improve respiratory efficiency. Participants were advised not to use analgesics for neck pain during the intervention period in order to reduce outcome contamination. Adherence was monitored throughout the treatment phase by supervised attendance and therapist oversight of exercise completion (29-32,44).

Pain intensity was measured using the Numeric Pain Rating Scale, an 11-point self-report scale ranging from 0 for no pain to 10 for worst imaginable pain. This measure was selected because of its established reliability and validity in musculoskeletal pain populations and its sensitivity to clinical change over time. Sleep disturbance was assessed using the Insomnia Severity Index, a 7-item instrument with total scores ranging from 0 to 28, where higher scores indicate greater insomnia severity. Neck-related disability was evaluated using the Urdu version of the Neck Disability Index, which quantifies functional limitation across 10 domains relevant to daily life. Deep cervical flexor endurance was assessed using the Craniocervical Flexion Test with pressure biofeedback, beginning from a 20 mmHg baseline and progressing in 2 mmHg increments up to 30 mmHg. For this test, participants performed gentle craniocervical flexion while the maximum pressure level sustained for 10 seconds was recorded, and the best of three trials was used in analysis. All outcomes were collected at baseline before intervention, at week 3, and at week 6 using the same procedural sequence and standardized administration methods to reduce measurement variability (44-56).

The primary analytical focus of the trial was comparative change over time in pain intensity, with endurance, sleep disturbance, and neck disability treated as key secondary outcomes. Demographic and baseline clinical characteristics were summarized using means and standard deviations for continuous variables and frequencies with percentages for categorical variables. Distributional assumptions were assessed using the Shapiro-Wilk test together with visual inspection of Q-Q plots and histograms. For within-group comparisons across time, parametric methods were used where assumptions of normality were satisfied, and non-parametric alternatives were applied where those assumptions were violated. For between-group comparisons at corresponding time points, independent-sample tests were used for normally distributed variables and Mann-Whitney U testing for non-normally distributed outcomes. Because baseline comparability is essential in randomized trials with repeated follow-up, baseline values were considered during between-group interpretation, and effect size estimation was used to complement p-values in judging clinical relevance. Statistical significance was set at $p<0.05$. Data were analyzed in IBM SPSS Statistics version 25 (33,44-56).

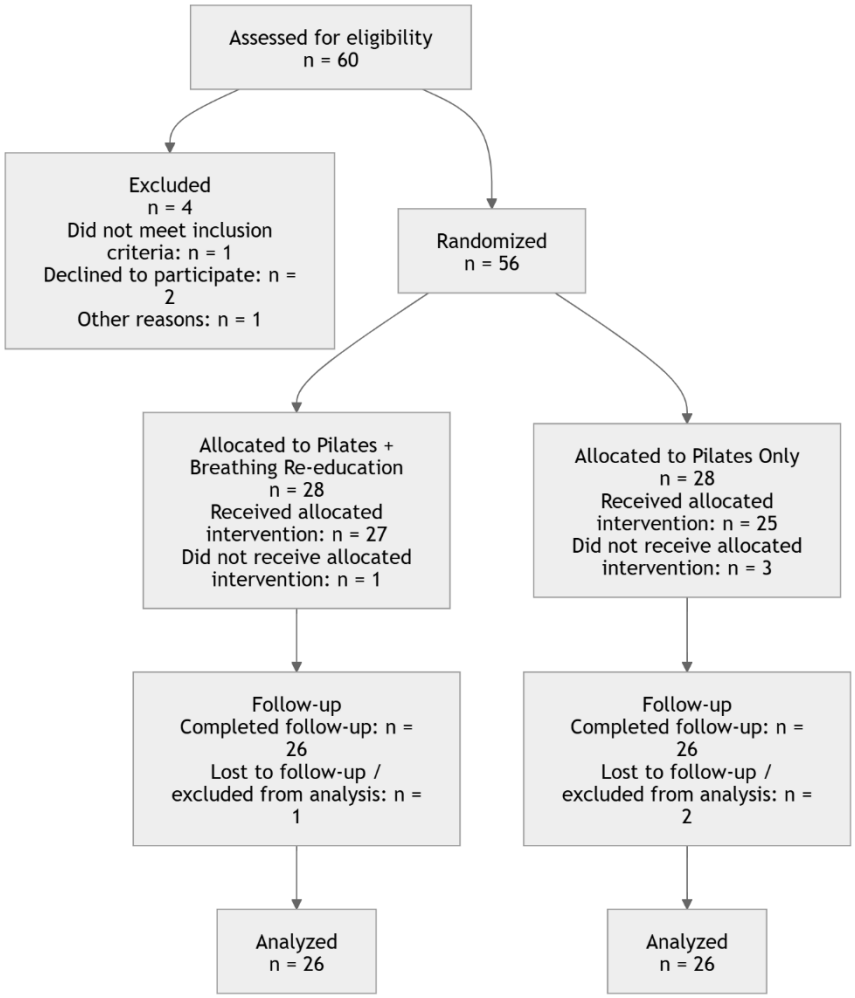


*Figure 2 CONSORT flow diagram showing participant screening, exclusion, randomization, allocation, follow-up, and analysis in the trial comparing Pilates plus breathing re-education with Pilates alone in working women with chronic non-specific neck pain.*

Several procedural measures were used to reduce bias and improve data integrity. Random allocation and concealed sequence implementation were used to minimize selection bias; blinded outcome assessment was used to reduce ascertainment bias; standardized eligibility screening and uniform treatment scheduling were used to limit procedural variability; and use of the same validated instruments at predefined intervals enhanced consistency of measurement. Reproducibility was further supported through fixed session duration, a prespecified intervention schedule, therapist supervision, and standardized recording of outcome data. Only participants who completed follow-up assessment were included in the final analysis dataset, ensuring that the reported findings reflected observed outcome values collected under the trial protocol.

## RESULTS

A total of 60 working women were screened for eligibility. Four were excluded before randomization, including one who did not meet the eligibility criteria, two who declined participation, and one excluded for other reasons. Fifty-six participants were randomized, with 28 allocated to the combined Pilates plus breathing re-education group and 28 to the Pilates-only group. During the intervention period, one participant from the combined intervention group and three from the Pilates-only group did not complete the allocated treatment. Consequently, 52 participants, 26 in each group, completed follow-up and were included in the final analysis. No adverse events or treatment-related complications were reported during the six-week intervention period. Baseline demographic characteristics were broadly comparable across groups in age, anthropometry, marital status, and occupational profile, supporting

reasonable clinical comparability at study entry, although the manuscript did not report formal baseline p-values for these variables.

*Table 1. Baseline demographic and occupational characteristics of the participants*

| Variable | Pilates + Breathing Re-education (n=26) | Pilates Only (n=26) | p-value |
|---|---|---|---|
| **Age, years** | 34.84 ± 7.64 | 36.50 ± 8.10 | NR |
| **Weight, kg** | 60.53 ± 5.42 | 59.80 ± 6.22 | NR |
| **Height, m** | 1.62 ± 0.04 | 1.62 ± 0.04 | NR |
| **Body mass index, kg/m²** | 22.76 ± 1.23 | 22.69 ± 1.14 | NR |
| **Married, n (%)** | 23 (88.5) | 20 (76.9) | NR |
| **Single, n (%)** | 3 (11.5) | 6 (23.1) | NR |
| **House officer, n (%)** | 5 (19.2) | 6 (23.1) | NR |
| **Doctor, n (%)** | 4 (15.4) | 4 (15.4) | NR |
| **Nurse, n (%)** | 4 (15.4) | 2 (7.7) | NR |
| **Teacher, n (%)** | 5 (19.2) | 3 (11.5) | NR |
| **Others, n (%)** | 8 (30.8) | 11 (42.3) | NR |

At outcome level, the combined intervention group demonstrated more favorable changes over time than the Pilates-only group across pain intensity, deep cervical flexor endurance, sleep disturbance, and neck-related disability. For pain, baseline scores were similar, and the difference at week 3 remained statistically non-significant. However, by week 6, the between-group comparison favored the combined intervention, with a Mann-Whitney U statistic of 64.5 and p=0.000. The repeated-measures analysis also showed a significant time effect at week 6, with $F(1,50)=56.367$, $p<0.001$, and $\eta^2=0.53$, indicating a large effect. Mean pain intensity in the combined intervention group decreased from 5.58±0.50 at baseline to 3.03±0.45 at week 6, corresponding to an absolute reduction of 2.55 points or approximately 45.7%, whereas the Pilates-only group declined from 5.42±0.70 to 4.15±0.61, an absolute reduction of 1.27 points or 23.4%.

*Table 2. Pain intensity over time and available inferential statistics*

| Outcome | Group | Baseline | Week 3 | Week 6 | Absolute Change (Baseline to Week 6) | Relative Change, % | Between-group statistic | p-value | Effect size |
|---|---|---|---|---|---|---|---|---|---|
| **NPRS** | Pilates + Breathing Re-education | 5.58 ± 0.50 | 4.65 ± 0.56 | 3.03 ± 0.45 | -2.55 | -45.7 | Week 6: U=64.5 | 0.000 | $\eta^2=0.53$* |
| **NPRS** | Pilates Only | 5.42 ± 0.70 | 4.92 ± 0.74 | 4.15 ± 0.61 | -1.27 | -23.4 | Week 3: U=261.0 | 0.111 | NR |

* Effect size reported in the manuscript for time effect at week 6: $F(1,50)=56.367$, $p<0.001$, $\eta^2=0.53$.

Endurance of the deep cervical flexors improved in both groups but to a much greater extent in the combined intervention arm. The manuscript reported no significant baseline difference in endurance (p=0.946), followed by significant between-group differences at both week 3 and week 6 (both $p<0.001$). In the combined intervention group, endurance increased from 18.42±1.27 mmHg at baseline to 22.46±1.17 mmHg at week 6, representing a gain of 4.04 mmHg or 21.9%. In contrast, the Pilates-only group improved from 18.35±1.09 mmHg to 19.38±1.06 mmHg, a gain of 1.03 mmHg or 5.6%. These values indicate a substantially steeper therapeutic response in the group receiving breathing re-education in addition to Pilates.

*Table 3. Endurance of deep cervical flexors over time and available inferential statistics*

| Outcome | Group | Baseline (mmHg) | Week 3 (mmHg) | Week 6 (mmHg) | Absolute Change | Relative Change, % | Baseline p-value | Week 3 p-value | Week 6 p-value |
|---|---|---|---|---|---|---|---|---|---|
| **CCFT endurance** | Pilates + Breathing Re-education | 18.42 ± 1.27 | 20.19 ± 1.20 | 22.46 ± 1.17 | +4.04 | +21.9 | 0.946 | <0.001 | <0.001 |
| **CCFT endurance** | Pilates Only | 18.35 ± 1.09 | 18.84 ± 0.92 | 19.38 ± 1.06 | +1.03 | +5.6 | 0.946 | <0.001 | <0.001 |

Sleep disturbance, assessed using the Insomnia Severity Index, also improved more substantially in the combined intervention group. The repeated-measures analysis showed statistically significant time effects in both groups, but the magnitude of change was notably greater in the combined intervention group, and the group-by-time interaction was significant. Mean ISI score in the combined intervention group declined from 17.38±3.51 at baseline to 11.65±3.19 at week 6, an absolute reduction of 5.73 points or 33.0%. The Pilates-only group showed a smaller reduction from 18.73±2.63 to 16.38±2.45, equivalent

to 2.35 points or 12.5%. This pattern suggests that addition of breathing re-education may have enhanced the effect of exercise on sleep-related symptom burden in this population.

*Table 4. Sleep disturbance over time and available inferential statistics*

| Outcome | Group | Baseline (ISI) | Week 3 (ISI) | Week 6 (ISI) | Absolute Change | Relative Change, % | Within-group statistic | p-value | Interaction |
|---|---|---|---|---|---|---|---|---|---|
| **ISI** | Pilates + Breathing Re-education | 17.38 ± 3.51 | 15.07 ± 3.45 | 11.65 ± 3.19 | -5.73 | -33.0 | F(2,49)=573.659 | <0.001 | Significant |
| **ISI** | Pilates Only | 18.73 ± 2.63 | 17.65 ± 2.53 | 16.38 ± 2.45 | -2.35 | -12.5 | F(2,49)=102.338 | <0.001 | Significant |

The combined intervention group also showed greater reduction in neck-related disability than the Pilates-only group. Mean NDI score fell from 24.73±5.35 at baseline to 13.46±5.51 at week 6 in the combined intervention group, an absolute reduction of 11.27 points or 45.6%. In the Pilates-only group, the score decreased from 24.08±4.76 to 20.65±4.54, a reduction of 3.43 points or 14.2%. The reported repeated-measures analysis showed significant time effects in both groups, with a significant group-by-time interaction, indicating that the magnitude of disability reduction was appreciably greater when breathing re-education was added to Pilates exercise.

*Table 5. Neck-related disability over time and available inferential statistics*

| Outcome | Group | Baseline (NDI) | Week 3 (NDI) | Week 6 (NDI) | Absolute Change | Relative Change, % | Within-group statistic | p-value | Interaction |
|---|---|---|---|---|---|---|---|---|---|
| **NDI** | Pilates + Breathing Re-education | 24.73 ± 5.35 | 19.50 ± 5.33 | 13.46 ± 5.51 | -11.27 | -45.6 | F(2,49)=114.441 | <0.001 | Significant |
| **NDI** | Pilates Only | 24.08 ± 4.76 | 22.57 ± 4.68 | 20.65 ± 4.54 | -3.43 | -14.2 | F(2,49)=32.587 | <0.001 | Significant |

To improve interpretability across outcomes with different measurement scales, the aggregate data were also re-expressed as relative six-week improvement from baseline. This cross-outcome comparison showed that the combined intervention produced approximately 45.7% improvement in pain, 21.9% improvement in endurance, 33.0% reduction in insomnia severity, and 45.6% reduction in disability, whereas the Pilates-only group showed corresponding changes of 23.4%, 5.6%, 12.5%, and 14.2%, respectively. The greatest between-group separation was observed for pain and disability, where relative improvement in the combined intervention group was more than threefold that seen in the Pilates-only group for disability and nearly double for pain.

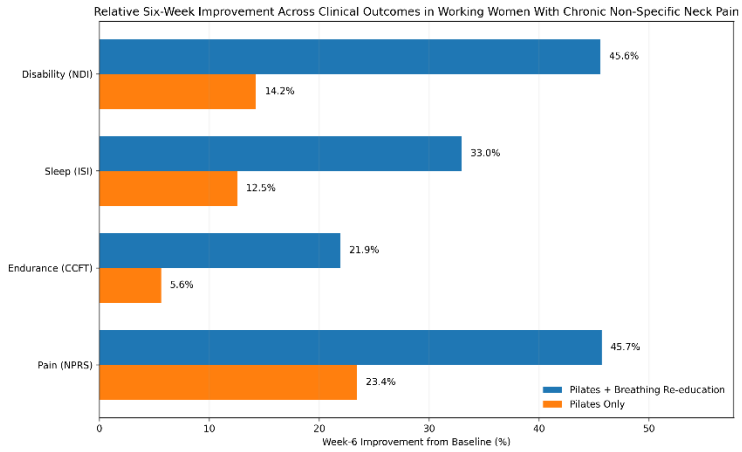


*Figure 3 Relative six-week improvement across clinical outcomes in working women with chronic non-specific neck pain*

Sleep improvement was also clinically notable, with the combined intervention achieving nearly 2.6 times the relative reduction observed in the Pilates-only arm. Endurance gains followed the same direction, with the combined intervention yielding almost a fourfold greater relative improvement than Pilates alone, supporting a more integrated therapeutic effect across symptom, functional, and physiological domains.

Across all four reported outcomes, the combined Pilates plus breathing re-education intervention demonstrated larger relative improvement from baseline to week 6 than Pilates alone. Pain intensity improved by 45.7% in the combined intervention group compared with 23.4% in the Pilates-only group, while neck disability improved by 45.6% versus 14.2%, respectively. Sleep disturbance showed a 33.0% reduction with the combined intervention compared with 12.5% with Pilates alone, and deep cervical flexor endurance increased by 21.9% versus 5.6%. The pattern indicates that the addition of breathing re-education was associated with consistently steeper clinical improvement across symptom severity, functional limitation, sleep burden, and cervical muscular performance, with the largest absolute separation observed for disability and pain.

## DISCUSSION

This randomized controlled trial evaluated whether adding breathing re-education to a structured Pilates program would yield greater improvement in pain intensity, deep cervical flexor endurance, sleep disturbance, and neck-related disability among working women with chronic non-specific neck pain. The findings consistently favored the combined intervention over Pilates alone at six weeks, with the largest relative gains observed for pain and disability and additional clinically meaningful improvements in sleep quality and cervical muscular endurance. These results support the view that chronic neck pain in occupationally active women is a multidimensional disorder that may respond more effectively to integrated exercise strategies than to movement-based rehabilitation alone. Rather than acting only through generalized exercise exposure, the combined protocol appears to have influenced multiple related domains simultaneously, suggesting that respiratory retraining may enhance the functional effects of cervical and postural exercise in this population.

The reduction in pain intensity observed in the combined intervention group is consistent with prior evidence suggesting that Pilates-based exercise can reduce pain by improving postural control, trunk stability, coordinated movement, and mechanical loading patterns across the spine. Earlier rehabilitation literature has reported that Pilates may serve as a useful non-pharmacological strategy for persistent musculoskeletal pain by improving movement quality and reducing maladaptive muscular recruitment. In the present study, pain scores in the combined intervention group decreased by 2.55 points over six weeks compared with 1.27 points in the Pilates-only group, indicating that the additional breathing component may have strengthened the analgesic response beyond what was achieved through exercise alone. This pattern is compatible with earlier reports that stabilization-oriented exercise and core-focused rehabilitation can reduce persistent spinal pain by improving neuromuscular efficiency and decreasing excessive muscular guarding (57,58).

The observed improvement in deep cervical flexor endurance also reinforces the rationale for combining breathing control with therapeutic exercise. Chronic non-specific neck pain is often associated with reduced activation efficiency of deep cervical stabilizers and compensatory overuse of superficial muscles, particularly when posture is compromised or respiratory mechanics are altered. In this trial, endurance increased by 4.04 mmHg in the combined intervention group compared with 1.03 mmHg in the Pilates-only group, suggesting a more substantial recovery in cervical motor performance when breathing retraining accompanied exercise. This may reflect improved coordination between cervical stabilization and respiratory muscle recruitment, especially if diaphragmatic breathing reduced accessory muscle overactivity and allowed more efficient neuromuscular control during repeated movement. Previous work on Pilates and functional performance has similarly indicated that structured training can improve muscular endurance and movement control, supporting the biological plausibility of the present findings (59).

One of the more clinically important findings of this study was the greater reduction in insomnia severity in the combined intervention group. Sleep disturbance is a major but often under-addressed consequence of chronic musculoskeletal pain, and its relationship with pain is likely reciprocal. In the

present study, the combined intervention reduced ISI scores by 5.73 points, whereas Pilates alone reduced scores by 2.35 points. This suggests that breathing re-education may have contributed benefits extending beyond biomechanical correction, potentially by promoting autonomic regulation, relaxation, and decreased physiological arousal. Diaphragmatic breathing has been associated in previous pain-management literature with reduced stress responsiveness and improved sleep-related outcomes, particularly when incorporated into mind-body or multimodal interventions. The present findings therefore align with the broader proposition that addressing respiratory and relaxation mechanisms alongside exercise may improve recovery in patients whose pain is accompanied by disturbed sleep and fatigue (60).

Similarly, the greater reduction in neck-related disability in the combined intervention group indicates that the benefits of the intervention were not limited to symptom relief but also extended to functional improvement. Disability scores declined by 11.27 points in the combined intervention group compared with 3.43 points in the Pilates-only group, suggesting a substantially larger functional gain when breathing re-education was incorporated. This is clinically relevant because improvement in disability reflects enhanced capacity to perform daily activities, tolerate occupational tasks, and manage pain-related limitations in real-world settings. Prior intervention studies in chronic neck pain have also shown that exercise-based approaches can improve disability when they target movement control, muscular performance, and pain-related functional restriction. The present results extend that literature by suggesting that a combined cervical-postural and respiratory approach may yield greater disability reduction than Pilates training alone in working women with persistent symptoms (61).

Taken together, the results suggest that the mechanism of benefit may be broader than simple strengthening or flexibility enhancement. Pilates likely contributed through improved postural alignment, segmental control, and cervical–core integration, whereas breathing re-education may have reduced excessive cervical accessory muscle activity, enhanced relaxation, and improved tolerance of movement and daily activity. The superiority of the combined intervention across all major outcomes supports a multimodal rehabilitation framework for chronic non-specific neck pain, particularly in populations exposed to prolonged occupational postures and stress-related symptom aggravation. This interpretation is consistent with prior literature emphasizing that chronic pain is best managed through integrated, multidimensional strategies rather than isolated symptom-targeted interventions (62).

Despite these strengths, the findings should be interpreted in light of several limitations. The final analyzed sample was modest, which restricts external validity and may reduce the precision of between-group estimates. The follow-up duration was limited to six weeks, so the persistence of treatment effects beyond the immediate intervention period remains uncertain. The trial was conducted only in working women, which improves population specificity but limits generalizability to men, non-working adults, or broader cervical pain populations. In addition, although the overall direction of findings was coherent across outcomes, the manuscript would be strengthened further by fuller reporting of confidence intervals, consistent effect-size estimates across all endpoints, and clearer specification of a single primary outcome. Nevertheless, the consistency of benefit across pain, endurance, sleep, and disability provides clinically meaningful support for the use of integrated exercise and breathing-based rehabilitation in this group.

## CONCLUSION

Pilates exercises combined with breathing re-education produced greater improvement than Pilates alone in pain intensity, deep cervical flexor endurance, sleep disturbance, and neck-related disability among working women with chronic non-specific neck pain over six weeks. The findings support the clinical value of an integrated rehabilitation approach that addresses both movement dysfunction and breathing behavior, particularly in patients whose symptoms are accompanied by impaired endurance, sleep disruption, and functional limitation. Although longer-term and larger-scale trials are needed to

confirm durability and broader applicability, the present results indicate that adding breathing re-education to Pilates may enhance short-term outcomes in this population.

## REFERENCES


1. Castellini G, Pillastrini P, Vanti C, Bargeri S, Giagio S, Bordignon E, et al. Some conservative interventions are more effective than others for people with chronic non-specific neck pain: a systematic review and network meta-analysis. J Physiother. 2022;68(4):244-54.
2. Dal Farra F, Buffone F, Risio RG, Tarantino AG, Vismara L, Bergna A. Effectiveness of osteopathic interventions in patients with non-specific neck pain: a systematic review and meta-analysis. Complement Ther Clin Pract. 2022;49:101655.
3. Henschke N, Kamper SJ, Maher CG. The epidemiology and economic consequences of pain. Mayo Clin Proc. 2015.
4. Qu N, Tian H, De Martino E, Zhang B. Neck pain: do we know enough about the sensorimotor control system? Front Comput Neurosci. 2022;16:946514.
5. Cohen SP. Epidemiology, diagnosis, and treatment of neck pain. Mayo Clin Proc. 2015.
6. Bernal-Utrera C, Gonzalez-Gerez JJ, Anarte-Lazo E, Rodriguez-Blanco C. Manual therapy versus therapeutic exercise in non-specific chronic neck pain: a randomized controlled trial. Trials. 2020;21:1-10.
7. Frost BA, Camarero-Espinosa S, Foster EJ. Materials for the spine: anatomy, problems, and solutions. Materials (Basel). 2019;12(2):253.
8. Rahman S. Anatomy, head and neck, cervical spine. 2020.
9. Buyukturan B, Guclu-Gunduz A, Buyukturan O, Dadali Y, Bilgin S, Kurt EE. Cervical stability training with and without core stability training for patients with cervical disc herniation: a randomized, single-blind study. Eur J Pain. 2017;21(10):1678-87.
10. Multanen J, Häkkinen A, Kautiainen H, Ylinen J. Associations of neck muscle strength and cervical spine mobility with future neck pain and disability: a prospective 16-year study. BMC Musculoskelet Disord. 2021;22:1-10.
11. Arimi SA, Bandpei MAM, Javanshir K, Rezasoltani A, Biglarian A. The effect of different exercise programs on size and function of deep cervical flexor muscles in patients with chronic nonspecific neck pain: a systematic review of randomized controlled trials. Am J Phys Med Rehabil. 2017;96(8):582-8.
12. Chan LLY, Wong AYL, Wang MH, Cheung K, Samartzis D. The prevalence of neck pain and associated risk factors among undergraduate students: a large-scale cross-sectional study. Int J Ind Ergon. 2020;76:102934.
13. Peng B, Yang L, Li Y, Liu T, Liu Y. Cervical proprioception impairment in neck pain-pathophysiology, clinical evaluation, and management: a narrative review. Pain Ther. 2021;10:143-64.
14. Chen X, O'Leary S, Johnston V. Modifiable individual and work-related factors associated with neck pain in 740 office workers: a cross-sectional study. Braz J Phys Ther. 2018;22(4):318-27.
15. Kazeminasab S, Nejadghaderi SA, Amiri P, Pourfathi H, Araj-Khodaei M, Sullman MJ, et al. Neck pain: global epidemiology, trends and risk factors. BMC Musculoskelet Disord. 2022;23:1-13.
16. Palacios-Ceña D, Albaladejo-Vicente R, Hernández-Barrera V, Lima-Florencio L, Fernández-de-Las-Peñas C, Jimenez-Garcia R, et al. Female gender is associated with a higher prevalence of chronic

neck pain, chronic low back pain, and migraine: results of the Spanish National Health Survey, 2017. Pain Med. 2021;22(2):382-95.

17. Hong JH, Lee DH, Kim SE, Seo DK. Correlation between contraction ratio, endurance, and muscle tone of cervical muscles. Phys Ther Rehabil Sci. 2020;9(4):302-8.

18. Lee MK, Oh J. The relationship between sleep quality, neck pain, shoulder pain and disability, physical activity, and health perception among middle-aged women: a cross-sectional study. BMC Womens Health. 2022;22(1):186.

19. Kagan R, Shiozawa A, Epstein AJ, Espinosa R. Impact of sleep disturbances on employment and work productivity among midlife women in the US SWAN database: a brief report. Menopause. 2021;28(10):1176-80.

20. Van Looveren E, Bilterys T, Munneke W, Cagnie B, Ickmans K, Mairesse O, et al. The association between sleep and chronic spinal pain: a systematic review from the last decade. J Clin Med. 2021;10(17):3836.

21. Lee SM, Lee CH, O'Sullivan D, Jung JH, Park JJ. Clinical effectiveness of a Pilates treatment for forward head posture. J Phys Ther Sci. 2016;28(7):2009-13.

22. Arif T, Rehman SSU, Ikram M. Effects of cervical stabilisation exercises on respiratory strength in chronic neck pain patients with forward head posture. J Pak Med Assoc. 2022;72:1635-8.

23. Awadallah MF, Sobh E, Shendy MA, Al-Shenqiti AM, Al-Jeraisi TM, Eweda RS. Impaired pulmonary function in patients with chronic neck pain. J Med Sci. 2021;41(3):123-8.

24. Ramirez MM, Shepherd MH, Melnick SJ, Hanebuth C, Bazemore C, Couce L, et al. Patient-reported outcome measures in physical therapy practice for neck pain: an overview of reviews. J Patient Rep Outcomes. 2023;7(1):97.

25. Fredin K, Lorås H. Manual therapy, exercise therapy or combined treatment in the management of adult neck pain-a systematic review and meta-analysis. Musculoskelet Sci Pract. 2017;31:62-71.

26. Cherkin DC, Herman PM. Cognitive and mind-body therapies for chronic low back pain and neck pain: effectiveness and value. JAMA Intern Med. 2018;178(4):556-7.

27. Wilhelm M, Cleland J, Carroll A, Marinch M, Imhoff M, Severini N, et al. The combined effects of manual therapy and exercise on pain and related disability for individuals with nonspecific neck pain: a systematic review with meta-analysis. J Man Manip Ther. 2023;31(6):393-407.

28. Stieven FF, Ferreira GE, Wiebusch M, de Araújo FX, da Rosa LHT, Silva MF. Dry needling combined with guideline-based physical therapy provides no added benefit in the management of chronic neck pain: a randomized controlled trial. J Orthop Sports Phys Ther. 2020;50(8):447-54.

29. Martini JD, Ferreira GE, de Araujo FX. Pilates for neck pain: a systematic review and meta-analysis of randomised controlled trials. J Bodyw Mov Ther. 2022;31:37-44.

30. Denham-Jones L, Gaskell L, Spence N, Pigott T. A systematic review of the effectiveness of Pilates on pain, disability, physical function, and quality of life in older adults with chronic musculoskeletal conditions. Musculoskeletal Care. 2022;20(1):10-30.

31. Mueller D, Redkva PE, de Borba EF, Barbosa SC, Krause MP, da Silva SG. Effect of mat vs. apparatus pilates training on the functional capacity of elderly women. J Bodyw Mov Ther. 2021;25:80-6.

32. Kashuba V, Tomilina Y, Byshevets N, Khrypko I, Stepanenko O, Grygus I, et al. Impact of Pilates on the intensity of pain in the spine of women of the first mature age. Phys Educ Theory Methodol. 2020;20(1):12-7.

33. Lim CY, In J. Randomization in clinical studies. Korean J Anesthesiol. 2019;72(3):221-32.

34. Sharif Z, Abid N, Ghani U, Shafique W, Raisham R. Effect of neck stabilization versus Pilates exercises on pain, quality of life and kinesiophobia in female office workers with non-specific chronic neck pain: a randomized control trial. Pak J Phys Ther. 2022.

35. Rodríguez-Sanz J, Malo-Urriés M, Corral-de-Toro J, López-de-Celis C, Lucha-López MO, Tricás-Moreno JM, et al. Does the addition of manual therapy approach to a cervical exercise program improve clinical outcomes for patients with chronic neck pain in short-and mid-term? A randomized controlled trial. Int J Environ Res Public Health. 2020;17(18):6601.

36. Nejati P, Lotfian S, Moezy A, Nejati M. The study of correlation between forward head posture and neck pain in Iranian office workers. Int J Occup Med Environ Health. 2015;28(2):295-303.

37. López-de-Uralde-Villanueva I, Beltran-Alacreu H, Fernández-Carnero J, La Touche R. Pain management using a multimodal physiotherapy program including a biobehavioral approach for chronic nonspecific neck pain: a randomized controlled trial. Physiother Theory Pract. 2020.

38. Kocur P, Wilski M, Lewandowski J, Łochyński D. Female office workers with moderate neck pain have increased anterior positioning of the cervical spine and stiffness of upper trapezius myofascial tissue in sitting posture. PM R. 2019;11(5):476-82.

39. De Zoete RM, Armfield NR, McAuley JH, Chen K, Sterling M. Comparative effectiveness of physical exercise interventions for chronic non-specific neck pain: a systematic review with network meta-analysis of 40 randomised controlled trials. Br J Sports Med. 2021;55(13):730-42.

40. Shin HJ, Kim SH, Hahm SC, Cho HY. Thermotherapy plus neck stabilization exercise for chronic nonspecific neck pain in elderly: a single-blinded randomized controlled trial. Int J Environ Res Public Health. 2020;17(15):5572.

41. Voulgarakis P, Iakovidis P, Lytras D, Chatziprodromidou IP, Kottaras A, Apostolou T. Effects of joint mobilization versus acupuncture on pain and functional ability in people with chronic neck pain: a randomized controlled trial of comparative effectiveness. Innov Acupunct Med. 2021;14(6):231-7.

42. Anan T, Kajiki S, Oka H, Fujii T, Kawamata K, Mori K, et al. Effects of an artificial intelligence-assisted health program on workers with neck/shoulder pain/stiffness and low back pain: randomized controlled trial. JMIR Mhealth Uhealth. 2021;9(9):e27535.

43. Cheon JH, Lim NN, Lee GS, Won KH, Lee SH, Kang EY, et al. Differences of spinal curvature, thoracic mobility, and respiratory strength between chronic neck pain patients and people without cervical pain. Ann Rehabil Med. 2020;44(1):58-68.

44. Pontes-Silva A, Avila MA, Fidelis-de-Paula-Gomes CA, Dibai-Filho AV. The Short-Form Neck Disability index has adequate measurement properties in chronic neck pain patients. Eur Spine J. 2021;30(12):3593-9.

45. Meerhoff GA, Verburg AC, Schapendonk RM, Cruijsberg J, Nijhuis-van der Sanden MW, van Dulmen SA, et al. Reliability, validity and discriminability of patient reported outcomes for non-specific low back pain in a nationwide physical therapy registry: a retrospective observational cohort study. PLoS One. 2021;16(6):e0251892.

46. Lubis CA, Tanjung D, Asrizal A. The effect of cold compress on pain intensity in fractured patients. J Keperawatan Soedirman. 2021;16(2).

47. Lee B, Kim YE. Validation of the Insomnia Severity Index among university students in Korea. OBM Neurobiol. 2023;7(4):1-14.

48. Jun J, Park CG, Kapella MC. Psychometric properties of the Insomnia Severity Index for people with chronic obstructive pulmonary disease. Sleep Med. 2022;95:120-5.

49. Alföldi P, Dragioti E, Wiklund T, Gerdle B. Spreading of pain and insomnia in patients with chronic pain: results from a national quality registry (SQRP). J Rehabil Med. 2017;49(1):63-70.

50. Farooq MN, Naz S, Kousar A, Shahzad K. Cross-cultural adaptation and validation of the Northwick park neck pain questionnaire to Urdu language. BMC Musculoskelet Disord. 2023;24(1):458.

51. Yalcinkaya H, Ucok K, Ulasli AM, Coban NF, Aydin S, Kaya I, et al. Do male and female patients with chronic neck pain really have different health-related physical fitness, depression, anxiety and quality of life parameters? Int J Rheum Dis. 2017;20(9):1079-87.

52. Farooq MN, Mohseni-Bandpei MA, Gilani SA, Hafeez A. Urdu version of the neck disability index: a reliability and validity study. BMC Musculoskelet Disord. 2017;18(1):149.

53. Jull GA, O'Leary SP, Falla DL. Clinical assessment of the deep cervical flexor muscles: the craniocervical flexion test. J Manipulative Physiol Ther. 2008;31(7):525-33.

54. Araujo FX, Ferreira GE, Scholl Schell M, Castro MP, Ribeiro DC, Silva MF. Measurement properties of the craniocervical flexion test: a systematic review. Phys Ther. 2020;100(7):1094-117.

55. Kotwani S, Bid D, Ghatamaneni D, Alahmari KA, Ramalingam T, Paul Silvian S. Determining the reliability of craniocervical flexion test in asymptomatic individuals. Hong Kong Physiother J. 2018;38(01):33-40.

56. Romeo A, Baccini M, Carreras G, Sagripanti M, Ruggeri M, Pillastrini P, et al. Reliability, validity, and responsiveness of the craniocervical flexion test in people who are asymptomatic and patients with nonspecific neck pain: a systematic review and meta-analysis. Phys Ther. 2022;102(7):pzac054.

57. Byrnes K, Wu PJ, Whillier S. Is Pilates an effective rehabilitation tool? A systematic review. J Bodyw Mov Ther. 2018;22(1):192-202.

58. Joyce AA, Kotler DH. Core training in low back disorders: role of the Pilates method. Curr Sports Med Rep. 2017;16(3):156-61.

59. Pereira MJ, Dias G, Mendes R, Mendes RS, Martins F, Gomes R, et al. Efficacy of Pilates in functional body composition: a systematic review. Appl Sci. 2022;12(15):7523.

60. Doorley J, Greenberg J, Stauder M, Vranceanu AM. The role of mindfulness and relaxation in improved sleep quality following a mind-body and activity program for chronic pain. Mindfulness (N Y). 2021;12(11):2672-80.

61. Sidiq M, Chahal A, Janakiraman B, Kashoo F, Kumar Kedia S, Kashyap N, et al. Effect of dynamic taping on neck pain, disability, and quality of life in patients with chronic non-specific neck pain: a randomized sham-control trial. PeerJ. 2024;12:e16799.

62. Morcillo-Muñoz Y, Castellano MHJ, Exposito FJD. Multimodal interventions to improve the management of chronic non-malignant pain in primary care using participatory research. 2021;11(3):561-81.