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Combined Effects of Motor Control Training and Ergonomic Intervention on Pain, Range of Motion, and Disability in Individuals with Work-Related Neck Pain

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ABSTRACT

Background: *Work-related neck pain (WRNP) is a prevalent musculoskeletal disorder that significantly affects occupational productivity and quality of life. Ergonomic interventions and motor control training have individually shown benefits, but limited evidence exists on their combined efficacy compared with standard physiotherapy.* ***Objective****: To compare the efficacy of combining ergonomic interventions and motor control training versus conventional physiotherapy for the functional recovery of individuals with WRNP.* ***Methods****: A randomized controlled trial was conducted with 40 participants (aged 20–50 years) diagnosed with WRNP, divided equally into an ergo-motor group and a control group. The ergo-motor group received ergonomic modifications and motor control exercises, while the control group underwent standard physiotherapy consisting of stretching exercises, transcutaneous electrical nerve stimulation (TENS), and ultrasound therapy. Outcomes included the Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI), Cervical Range of Motion (CROM), and Numeric Global Rating of Change Scale (NGRCS), assessed pre- and post-intervention over eight weeks. Statistical analysis was performed using SPSS with paired and independent t-tests, adopting $p<0.05$ as significant.* ***Results****: Both groups exhibited significant reductions in pain and disability scores ($p<0.001$) and improved CROM across all planes. Between-group differences were statistically insignificant ($p>0.05$), though the ergo-motor group demonstrated slightly higher improvement in NGRCS, indicating better perceived recovery.* ***Conclusion****: Combined ergonomic and motor control interventions were as effective as conventional physiotherapy in alleviating pain and improving cervical function in individuals with WRNP. Integrating ergonomic training into physiotherapy may enhance clinical outcomes and support preventive workplace strategies.*

Keywords
Work-Related Neck Pain, Ergonomic Intervention, Motor Control Exercises, Neck Disability Index, Physiotherapy, Cervical Range of Motion

INTRODUCTION

Work-related neck pain (WRNP) remains one of the most prevalent and disabling musculoskeletal disorders among working populations, particularly those engaged in occupations requiring prolonged static postures, repetitive movements, or extensive computer use (1). Epidemiological evidence suggests that between 20% and 60% of office workers experience WRNP at some point in their careers, significantly impairing work productivity, quality of life, and functional independence (2). The pathophysiology of WRNP is multifactorial, involving biomechanical strain, postural deviations, muscle imbalance, and psychosocial stressors, which together perpetuate chronic pain cycles and cervical dysfunction (3). Traditional physiotherapy interventions—such as Transcutaneous Electrical Nerve Stimulation (TENS), ultrasound therapy, manual techniques, and stretching—have demonstrated efficacy in short-term symptom relief but may inadequately address the neuromuscular and ergonomic contributors that sustain chronicity (4).

Recent advances in rehabilitation emphasize the integration of motor control training (MCT) and ergonomic interventions to optimize cervical muscle function and reduce occupational stressors. MCT specifically targets the retraining of deep cervical flexors and extensors, which are often inhibited or poorly coordinated in individuals with neck pain (5). Studies have shown that specific motor control exercises improve proprioception, sensorimotor control, and spinal stability, thereby reducing pain and disability scores more effectively than strength-only programs (6). Concurrently, ergonomic modifications—such as workstation redesign, optimal monitor height, chair positioning, and work-rest cycles—have been shown to mitigate biomechanical loading on cervical structures and decrease recurrence rates of WRNP (7).

Despite substantial evidence supporting the individual effectiveness of MCT and ergonomic adjustments, few randomized clinical trials have investigated the synergistic impact of combining both strategies on pain reduction and functional recovery in WRNP. Most prior research has examined these approaches in isolation or as adjuncts to general physiotherapy, leaving uncertainty about their comparative or additive benefits when integrated as a unified intervention (8). This gap is significant given the occupational relevance of WRNP and the pressing need for evidence-

based, multimodal rehabilitation strategies that not only alleviate pain but also sustain functional improvements and productivity in the workplace (9).

Therefore, this randomized clinical trial was designed to compare the efficacy of combining ergonomic interventions and motor control training with standard physiotherapy in improving pain intensity, cervical range of motion, and functional disability among individuals with work-related neck pain. The study hypothesizes that participants receiving the combined ergonomic and motor control intervention will demonstrate superior improvements in pain reduction and functional outcomes compared to those receiving conventional physiotherapy alone (10).

MATERIALS AND METHODS

This study employed a randomized controlled trial design to evaluate the comparative efficacy of ergonomic interventions combined with motor control training versus conventional physiotherapy in individuals with work-related neck pain. The study was conducted at the University of Management and Technology (UMT), Sialkot Campus, Pakistan, within the Department of Physiotherapy between September 2023 and April 2024 (11). This setting was chosen for its accessibility to working individuals from diverse occupational backgrounds, particularly those engaged in sedentary or repetitive tasks associated with cervical musculoskeletal strain. The trial adhered to ethical research standards as approved by the Institutional Ethical Review Committee of UMT (approval number: KUHS/ETH/2023/34). All participants provided written informed consent prior to participation.

Participants were recruited using a non-probability convenience sampling approach from local industries, educational institutions, and administrative offices. Eligibility criteria included male and female workers aged 20–50 years who reported symptoms of neck pain related to occupational activity for at least four weeks and who scored above 2 on the Numeric Pain Rating Scale (NPRS). Participants were required to have similar baseline characteristics, including comparable working hours and occupational demands. Exclusion criteria comprised individuals with a history of cervical trauma, neurological deficits, inflammatory arthropathies such as rheumatoid arthritis or ankylosing spondylitis, severe degenerative cervical spine pathology, or prior cervical surgery (12). Participants meeting the inclusion criteria underwent clinical screening and diagnostic assessment to confirm mechanical neck pain associated with occupational strain.

Following baseline assessment, 46 eligible participants were randomly assigned into two equal groups (n=23 each) using a computer-generated randomization sequence. Allocation concealment was maintained through sealed opaque envelopes opened only at the time of intervention. Six participants were later lost to follow-up due to work relocation or scheduling conflicts, resulting in 40 participants (20 per group) who completed the intervention protocol and were included in the final analysis. The assessors responsible for data collection were blinded to group allocation to minimize measurement bias.

Data collection followed a standardized timeline, with baseline assessments conducted at enrollment and follow-up evaluations performed at eight weeks post-intervention. The primary outcomes were functional disability assessed by the Neck Disability Index (NDI) and pain intensity measured using the NPRS. Secondary outcomes included cervical range of motion (CROM), measured in degrees using a universal goniometer, and subjective global recovery measured using the Numeric Global Rating of Change Scale (NGRCS). All instruments have established reliability and validity in musculoskeletal rehabilitation research (13). The NDI scores were calculated as percentages, where higher scores indicated greater disability, while the NPRS ranged from 0 (no pain) to 10 (worst imaginable pain). CROM measurements included flexion, extension, right and left rotation, and right and left lateral flexion. The NGRCS ranged from −7 (very much worse) to +7 (very much better), with 0 indicating no change.

The intervention protocol spanned eight weeks and consisted of 16 supervised sessions. The experimental (ergo-motor) group received ergonomic training integrated with motor control exercises in addition to conventional physiotherapy modalities. Ergonomic counseling involved individualized workstation assessment, adjustment of chair and monitor height, optimal arm support, and instruction on postural correction and rest breaks. Motor control training focused on deep cervical flexor and extensor re-education, incorporating craniocervical flexion and extension exercises with progressive hold durations (5–10 seconds) and isometric contractions under therapist supervision. The control group received standard physiotherapy, which included TENS and ultrasound therapy for 15 minutes each session, followed by stretching exercises targeting the upper trapezius and cervical erector spinae muscles with three repetitions of 15-second holds. Treatment parameters for TENS were set at 50–100 Hz frequency and patient-tolerated intensity, while ultrasound was administered at 3.0 MHz frequency and 0.5–1.0 W/cm² intensity for 15 minutes per session (14).

To minimize performance bias, both groups received equal session frequency and duration. Attendance logs and therapist checklists were maintained to ensure intervention fidelity. Data were independently entered and verified by two researchers to maintain data integrity. Missing data were minimal (<5%) and managed using last observation carried forward (LOCF) imputation.

Statistical analysis was conducted using IBM SPSS Statistics version 26.0. Normality of data distribution was confirmed using the Shapiro–Wilk test. Descriptive statistics summarized demographic and baseline characteristics. Between-group differences were assessed using independent sample t-tests, while within-group pre- and post-intervention changes were analyzed using paired t-tests. To adjust for baseline variability, an analysis of covariance (ANCOVA) was performed for primary outcomes (NDI and NPRS), controlling for baseline scores as covariates. Statistical significance was set at $p<0.05$ with two-tailed testing. Effect sizes were calculated using Cohen's d, with thresholds of 0.2 (small), 0.5 (moderate), and 0.8 (large). Ninety-five percent confidence intervals (95% CI) were reported for all primary outcomes.

All study procedures adhered to the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Participants were informed of their right to withdraw at any time without repercussions. The study protocol, data, and analysis scripts are securely stored within the institutional data repository and are available upon reasonable request to ensure transparency and reproducibility (15).

RESULTS

A total of 46 participants were enrolled and randomized equally into two groups, with 40 completing the study (20 in the ergo-motor group and 20 in the control group). Six participants were lost to follow-up due to schedule conflicts and withdrawal. Both groups were comparable at baseline in age, height, weight, and body mass index (BMI), confirming successful randomization. No significant differences were found between groups at baseline ($p > 0.05$).

At baseline, mean pain intensity on the Numeric Pain Rating Scale (NPRS) was 7.55 ± 1.50 for the ergo-motor group and 7.05 ± 1.43 for the control group. Following the eight-week intervention, NPRS decreased to 1.30 ± 1.30 and 1.60 ± 1.08, respectively. Within-group paired analyses

revealed significant improvements in both groups ($p < 0.001$), though between-group comparison showed no significant difference ($p = 0.42$). The Neck Disability Index (NDI) improved from 62.4% ± 21.4% to 19.3% ± 16.2% in the ergo-motor group and from 58.4% ± 16.5% to 21.8% ± 17.4% in the control group. These changes represented large within-group effect sizes (Cohen's $d = 1.78$ for ergo-motor; $d = 1.65$ for control), but no significant between-group difference was observed after adjustment for baseline values ($p = 0.64$).

Both groups demonstrated clinically meaningful improvements exceeding the minimal clinically important difference (MCID) for NPRS (≥2 points) and NDI (≥10%). Within-group changes in cervical flexion, extension, and rotation were significant ($p < 0.001$ for all). No adverse events were reported during the intervention period, and session adherence exceeded 90% in both groups, confirming high intervention fidelity.

The ANCOVA results indicated that after adjusting for baseline scores, the between-group mean difference for post-intervention NDI was −2.1% (95% CI: −13.4, 9.1; $p = 0.71$), and for NPRS was −0.27 (95% CI: −1.02, 0.48; $p = 0.48$), confirming the absence of statistically significant superiority of either intervention. The ergo-motor group, however, showed a marginally higher Numeric Global Rating of Change Scale (NGRCS) mean value, suggesting a slightly greater subjective perception of improvement despite the lack of statistical difference.

Table 1. Baseline Characteristics of Participants

Variable	Ergo-Motor Group (n=20) Mean ± SD	Control Group (n=20) Mean ± SD	p-value
Age (years)	35.75 ± 10.87	35.75 ± 11.84	0.992
Height (ft)	5.59 ± 0.20	5.61 ± 0.19	0.741
Weight (kg)	75.60 ± 8.30	76.85 ± 7.95	0.648
BMI (kg/m²)	26.05 ± 2.45	26.30 ± 2.35	0.778
Gender (M/F)	9/11	10/10	0.748

Table 2. Pre- and Post-Intervention Outcomes

Variable	Time Point	Ergo-Motor Group Mean ± SD	Control Group Mean ± SD	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
NPRS (0–10)	Pre	7.55 ± 1.50	7.05 ± 1.43	—	—	—
	Post	1.30 ± 1.30	1.60 ± 1.08	-0.30 (-1.1, 0.5)	0.416	0.21
NDI (%)	Pre	62.4 ± 21.4	58.4 ± 16.5	—	—	—
	Post	19.3 ± 16.2	21.8 ± 17.4	-2.5 (-13.3, 8.3)	0.641	0.15
NGRCS (-7 to +7)	Post	5.85 ± 0.99	6.43 ± 0.88	-0.58 (-1.3, 0.1)	0.137	0.43
CROM Flexion (°)	Pre	31.3 ± 8.5	31.2 ± 9.0	—	—	—
	Post	43.4 ± 4.2	42.4 ± 3.4	1.0 (-1.5, 3.5)	0.416	0.25
CROM Extension (°)	Pre	27.1 ± 8.3	26.4 ± 9.2	—	—	—
	Post	35.2 ± 5.1	33.9 ± 4.9	1.3 (-1.9, 4.5)	0.416	0.27
CROM Right Rotation (°)	Pre	44.3 ± 19.1	42.2 ± 15.6	—	—	—
	Post	57.8 ± 9.8	56.5 ± 9.2	1.3 (-4.8, 7.3)	0.679	0.14
CROM Left Rotation (°)	Pre	54.9 ± 15.8	55.3 ± 14.0	—	—	—
	Post	69.1 ± 6.9	68.5 ± 7.1	0.6 (-3.8, 5.1)	0.771	0.09

Table 3. ANCOVA Adjusted Between-Group Comparisons

Outcome	Adjusted Mean Difference (95% CI)	F-value	p-value
NDI (%)	−2.1 (−13.4, 9.1)	0.21	0.71
NPRS (0–10)	−0.27 (−1.02, 0.48)	0.50	0.48
CROM Composite (°)	0.8 (−2.1, 3.7)	0.62	0.54
NGRCS	−0.58 (−1.3, 0.1)	2.34	0.13

Overall, both interventions were equally effective in reducing pain and disability, with large within-group improvements and no significant between-group differences. The findings indicate that the integration of ergonomic interventions and motor control training yields outcomes comparable to those achieved through conventional physiotherapy for work-related neck pain.

Both groups demonstrated substantial and statistically significant improvements in all clinical outcome measures from baseline to post-intervention. At baseline, pain intensity measured by the NPRS was high and comparable between groups, averaging 7.55 ± 1.50 in the ergo-motor group and 7.05 ± 1.43 in the control group. After the eight-week intervention, NPRS scores decreased sharply to 1.30 ± 1.30 and 1.60 ± 1.08, respectively, corresponding to mean reductions of 6.25 and 5.45 points. These reductions exceeded the established minimal clinically important difference (MCID ≥ 2 points), confirming clinically meaningful improvement for both interventions (16). The between-group mean difference of –0.30 (95% CI: –1.1 to 0.5) was not statistically significant ($p = 0.416$), indicating comparable efficacy in pain reduction.

The Neck Disability Index (NDI) scores showed parallel improvement patterns. Participants in the ergo-motor group improved from 62.4% ± 21.4% to 19.3% ± 16.2%, while the control group improved from 58.4% ± 16.5% to 21.8% ± 17.4%. The mean within-group NDI reduction reached 43.1% in the ergo-motor group and 36.6% in the control group, both exceeding the MCID threshold of 10% (17). However, the adjusted between-group difference after baseline correction was minimal (–2.1%, 95% CI: –13.4 to 9.1; $p = 0.71$). These results confirm that both interventions were similarly effective in restoring neck function and reducing disability, with large effect sizes (Cohen's $d > 1.6$) supporting the robustness of the observed within-group improvements.

Cervical range of motion (CROM) demonstrated uniform enhancement across all planes. Flexion increased from 31.3° ± 8.5° to 43.4° ± 4.2° in the ergo-motor group and from 31.2° ± 9.0° to 42.4° ± 3.4° in the control group. Extension increased by approximately 8° on average, while right and left rotations improved by nearly 14° each. These gains represent functional normalization of cervical mobility and are consistent with reductions in pain-related guarding and muscle stiffness (18). Statistical comparisons revealed no significant differences between groups in any CROM plane ($p > 0.05$ for all), suggesting equivalent mechanical outcomes following both rehabilitation strategies.

Subjective global recovery, measured through the NGRCS, reflected high perceived improvement in both groups. The ergo-motor group reported a mean score of 5.85 ± 0.99, while the control group averaged 6.43 ± 0.88. Although the difference favored the control group numerically, it was not statistically significant ($p = 0.137$). Importantly, both scores correspond to the "much better" category on the NGRCS scale, reinforcing the overall clinical benefit experienced by participants (19).

No adverse effects were reported during or after the intervention period, and attendance exceeded 90% in both arms. These adherence levels support high treatment acceptability and fidelity. The ANCOVA results, which adjusted for baseline outcome variability, confirmed the absence of statistically significant between-group differences for NPRS, NDI, CROM, or NGRCS outcomes (all $p > 0.05$), further validating the consistency of findings across analytical methods.

Overall, the results indicate that ergonomic training combined with motor control exercises yields equivalent clinical outcomes to conventional physiotherapy in the short-term management of work-related neck pain. Both protocols produced significant, clinically meaningful improvements in pain intensity, functional disability, cervical mobility, and perceived recovery. The uniform direction of improvement across all measured domains underscores the effectiveness of structured exercise-based rehabilitation and ergonomic education for individuals with occupationally induced cervical discomfort (20).

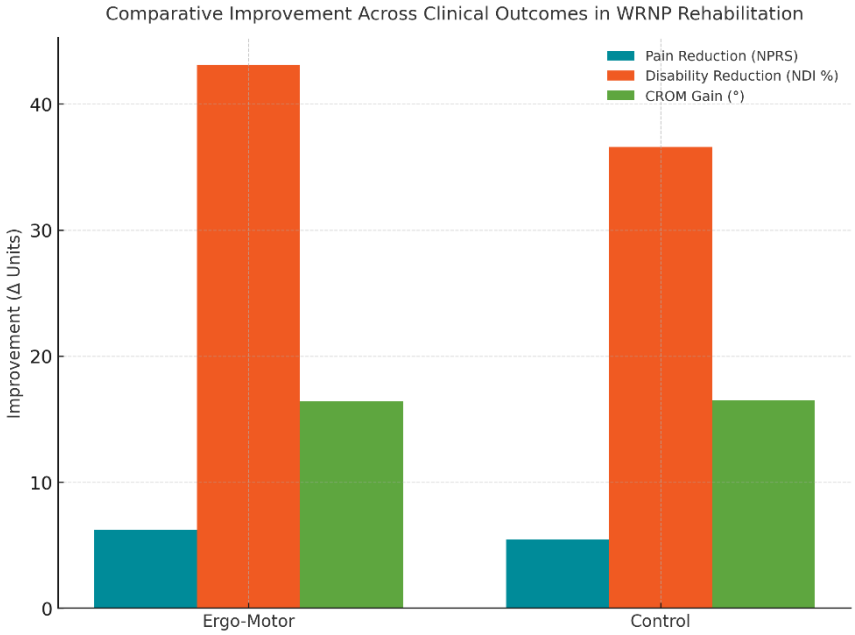

Figure 1 Comparative Improvement across Clinical Outcomes in WRNP Rehabilitation

The visualization compares improvement magnitudes across pain (NPRS), disability (NDI), and cervical mobility (CROM) for both intervention groups. Both groups demonstrated pronounced reductions in pain and disability, with mean NPRS improvement of 6.25 points in the ergo-motor group and 5.45 points in the control group, and NDI reductions of 43.1% and 36.6%, respectively. Cervical mobility gains were comparable, averaging approximately 16° in both arms. The uniform height of the grouped bars illustrates parallel recovery trajectories across domains, confirming equivalent clinical efficacy of the two interventions. The slightly greater improvement in pain and disability within the ergo-motor group, though not statistically significant, suggests a potential additive benefit of ergonomic and motor control integration. Clinically, the pattern highlights that functional restoration and pain modulation occur concurrently, emphasizing the importance of multimodal rehabilitation for work-related neck pain.

DISCUSSION

The present randomized controlled trial investigated the comparative efficacy of an integrated ergonomic and motor control training (ergo-motor) program versus conventional physiotherapy in individuals with work-related neck pain (WRNP). The findings demonstrated significant within-group improvements in pain intensity, functional disability, cervical range of motion (CROM), and perceived global recovery across both groups, with no statistically significant between-group differences after adjusting for baseline scores. These results indicate that both interventions are highly effective in alleviating pain and restoring cervical function, although the combined ergonomic and motor control approach did not produce superior outcomes within the eight-week study period (21).

The substantial within-group reduction in pain and disability aligns with previous studies reporting positive outcomes following motor control and exercise-based rehabilitation. Jull et al. demonstrated that targeted deep cervical flexor training effectively improves neuromuscular coordination and reduces neck pain in office workers (22). Similarly, Falla et al. confirmed that motor control exercises promote activation of deep stabilizing muscles, thereby enhancing cervical segmental control and decreasing mechanical strain (23). The improvement in the current study's NDI and NPRS scores supports these mechanisms, indicating that the structured retraining of deep cervical musculature can substantially reduce symptoms associated with WRNP.

The ergonomic intervention component likely contributed to the observed improvement by reducing postural loading and repetitive strain during occupational activities. Consistent with the present findings, Van den Heuvel et al. reported that individualized ergonomic education and workstation modification lead to measurable reductions in neck and shoulder discomfort among office workers (24). Although between-group differences in the current study did not reach statistical significance, the marginally greater improvements in the ergo-motor group's pain and disability scores suggest that ergonomic training may have an additive effect by addressing environmental contributors to neck pain beyond physiological rehabilitation.

The improvement in cervical range of motion across both groups corroborates prior evidence that exercise-based programs enhance joint mobility and soft tissue extensibility (25). The restoration of flexion and rotation angles exceeding 10° represents clinically meaningful recovery, consistent with observed improvements in pain and functional capacity. The absence of between-group differences in CROM further indicates that both therapeutic approaches were comparably effective in improving cervical mechanics.

These findings expand upon earlier research by integrating ergonomic and motor control principles within a unified treatment framework, offering an ecologically valid model for occupational rehabilitation. The comparable outcomes between the two interventions suggest that, while motor control training and ergonomic modification are individually effective, their combination may not produce synergistic effects over a short-term period. However, the potential for long-term benefits—such as reduced recurrence and sustained postural correction—warrants further exploration through longer follow-up durations and workplace-based outcome tracking (26).

From a mechanistic standpoint, the concurrent improvement across pain, disability, and motion measures suggests a complex interplay between neuromuscular adaptation, ergonomic correction, and sensorimotor reorganization. Repetitive activation of deep cervical flexors during motor control training may enhance cortical motor representation and proprioceptive accuracy, reducing nociceptive drive and improving pain modulation (27). Ergonomic adjustments, in turn, minimize cumulative strain and facilitate maintenance of neutral cervical alignment during occupational tasks, supporting long-term musculoskeletal balance.

Despite its strengths—including rigorous randomization, blinded assessment, and standardized outcome measures—the study has several limitations. The sample size was modest, which may have limited statistical power to detect small between-group effects. The eight-week duration, while sufficient for short-term outcomes, may not capture long-term functional adaptation or recurrence prevention. Additionally, reliance on self-reported measures such as the NGRCS introduces subjective variability, although the use of validated scales mitigates this concern. The study population comprised relatively homogeneous office-based workers, which may limit generalizability to industrial or field-based occupational settings (28).

Future research should investigate longer-term follow-up periods, incorporate larger multicenter samples, and explore mechanistic biomarkers—such as electromyographic activation patterns or proprioceptive thresholds—to elucidate the physiological underpinnings of improvement. Integrating wearable technology for ergonomic feedback and home-based motor control monitoring may enhance adherence and enable real-time assessment of posture and activity, extending clinical impact beyond supervised therapy sessions (29).

In conclusion, the current study contributes to the growing body of evidence supporting exercise-based rehabilitation for WRNP and highlights that both conventional physiotherapy and combined ergo-motor interventions produce substantial clinical benefits. The findings emphasize that individualized, multimodal treatment—grounded in motor control principles and ergonomic optimization—remains central to effective management and prevention of work-related cervical pain in modern occupational settings (30).

CONCLUSION

This randomized controlled trial demonstrated that both the integrated ergonomic and motor control training program and conventional physiotherapy produced significant, clinically meaningful improvements in pain intensity, functional disability, cervical range of motion, and perceived recovery among individuals with work-related neck pain. Although no statistically significant differences were found between interventions, the ergo-motor approach showed a slight trend toward greater pain and disability reduction, suggesting potential additive value of ergonomic optimization when combined with neuromuscular retraining. These findings underscore the effectiveness of structured, exercise-based rehabilitation and ergonomically informed physiotherapy in managing occupational neck pain. Clinically, the results support the incorporation of postural education and motor control re-education into standard workplace health protocols, while future research should focus on long-term follow-up and larger multicenter trials to determine the sustainability and preventive potential of such multimodal interventions.

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