The impact of a combined rehabilitation protocol on cardiovascular risk markers and neck disability in hypertensive patients following thyroidectomy: a randomized controlled trial

Impacto de un protocolo de rehabilitación combinado sobre los marcadores de riesgo cardiovascular y la discapacidad cervical en pacientes hipertensos tras tiroidectomía: un ensayo controlado aleatorizado

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Abstract

This study investigated the effectiveness of combining sensorimotor training and the McKenzie technique on cardiovascular risk markers and neck disability in hypertensive patients following thyroidectomy. In a randomized, single-blind controlled trial, 40 hypertensive female patients who underwent total thyroidectomy were equally divided into two groups. The intervention group (A) received a combined protocol of sensorimotor training, McKenzie exercises, and active stretching, while the control group (B) received only active stretching exercises. The interventions were administered three times per week for six weeks. Results demonstrated that the intervention group achieved significantly superior outcomes in both cardiovascular and functional parameters. Group A showed notable reductions in systolic BP (6.21%), diastolic BP (6.64%), and resting heart rate (7.92%), alongside significantly greater improvements in cervical ROM (flexion: 35.08%, lateral flexion: 42.14-42.92%) compared to Group B. Most notably, the reduction in neck disability was substantially greater in the intervention group (56.58%) versus the control group (23.38%), with a very large effect size ($d=2.48$, $p < 0.001$). These findings suggest that the combined protocol effectively addresses both biomechanical stress and cardiovascular risk in post-thyroidectomy hypertensive patients. Integrating this multimodal approach into postoperative care could lead to enhanced functional recovery and improved cardiometabolic health outcomes.

Keywords: McKenzie Exercises, Sensorimotor Training, Cardiovascular Risk, Hypertension, Thyroidectomy, Neck Disability, Blood Pressure.

Resumen

Este estudio investigó la eficacia de combinar el entrenamiento sensoriomotor y la técnica McKenzie sobre los marcadores de riesgo cardiovascular y la discapacidad cervical en pacientes hipertensos tras tiroidectomía. En un ensayo controlado aleatorizado simple ciego, 40 pacientes hipertensas de sexo femenino sometidas a tiroidectomía total se dividieron equitativamente en dos grupos. El grupo de intervención (A) recibió un protocolo combinado de entrenamiento sensoriomotor, ejercicios McKenzie y estiramientos activos, mientras que el grupo de control (B) recibió únicamente ejercicios de estiramiento activos. Las intervenciones se administraron tres veces por semana durante seis semanas. Los resultados demostraron que el grupo de intervención obtuvo resultados significativamente superiores tanto en los parámetros cardiovasculares como funcionales. El grupo A mostró reducciones notables en la presión arterial sistólica (6,21 %), la presión arterial diastólica (6,64 %) y la frecuencia cardíaca en reposo (7,92 %), junto con mejoras significativamente mayores en el rango de movimiento cervical (flexión: 35,08 %, flexión lateral: 42,14-42,92 %) en comparación con el grupo B. Cabe destacar que la reducción de la discapacidad cervical fue sustancialmente mayor en el grupo de intervención (56,58 %) que en el grupo de control (23,38 %), con un tamaño del efecto muy grande ($d = 2,48$, $p < 0,001$). Estos hallazgos sugieren que el protocolo combinado aborda eficazmente tanto el estrés biomecánico como el riesgo cardiovascular en pacientes hipertensos post-tiroidectomía. La integración de este enfoque multimodal en la atención postoperatoria podría conducir a una mejor recuperación funcional y a mejores resultados de salud cardiometabólica.

Palabras clave: Ejercicios de McKenzie, Entrenamiento sensoriomotor, Riesgo cardiovascular, Hipertensión, Tiroidectomía, Discapacidad cervical, Presión arterial

Introduction

Thyroidectomy, the surgical removal of all or part of the thyroid gland, is a fundamental procedure for managing thyroid carcinoma, multinodular goiter, and benign nodules[1]. While its clinical success is well-established, a significant number of patients experience persistent postoperative musculoskeletal complications, with chronic neck pain and disability being highly prevalent[2]. The etiology of this dysfunction is multifactorial, often arising from prolonged intraoperative neck hyperextension, soft tissue trauma, and postoperative scar formation, leading to pain, stiffness, and a significant reduction in cervical range of motion (ROM)[3].

Beyond its direct musculoskeletal impact, thyroid disease and its treatment have profound implications for cardiovascular health. Both hypothyroidism and hyperthyroidism are recognized for their ability to disrupt hemodynamic stability and are established secondary causes of hypertension[4]. Furthermore, a growing body of evidence identifies chronic musculoskeletal pain, particularly in the cervical region, as an independent risk factor for the development and exacerbation of cardiovascular disease (CVD)[5,6]. The proposed pathophysiological link involves the sustained activation of the sympathetic nervous system and dysregulation of the autonomic nervous system (ANS)[7]. Chronic neck pain can lead to a state of increased sympathetic tone, which manifests as elevated resting heart rate, increased systemic vascular resistance, and consequently, hypertension[8]. This creates a vicious cycle where pain drives cardiovascular stress, which in turn may sensitize patients to perceive pain more intensely.

Conventional physical therapy for post-thyroidectomy neck dysfunction has traditionally focused on restoring joint mobility and flexibility through modalities like postural re-education and active stretching exercises[9]. While beneficial for improving ROM[10-12], this approach may be insufficient as it fails to address the underlying neuromuscular and sensorimotor deficits that accompany chronic neck conditions. Patients frequently exhibit diminished joint position sense, altered muscle recruitment patterns, and impaired postural control, indicating a significant disruption in the integration of sensory input and motor output[5]. From a biomechanical standpoint, these alterations increase mechanical stress on cervical structures, perpetuating a cycle of pain and dysfunction[3].

To effectively break this cycle, a multifaceted rehabilitation strategy is necessary. Sensorimotor training has emerged as a powerful intervention to address the neuromuscular components of neck dysfunction. By challenging the proprioceptive, visual, and vestibular systems, this training aims to recalibrate the sensorimotor loop, improve postural stability, and normalize motor

control, thereby reducing aberrant stress on cervical structures[13,14]. Complementing this, the McKenzie method of Mechanical Diagnosis and Therapy (MDT) offers a structured, patient-empowering approach that utilizes repeated end-range movements to centralize pain, restore spinal mobility, and reduce mechanical strain[8,9]. Its emphasis on extension-based exercises is particularly relevant for countering the common post-surgical tendency towards a protective flexed posture[15,16].

Therefore, this study was designed to investigate a novel, combined therapeutic approach with a dual focus. We posit that the chronic pain and mechanical stress following thyroidectomy contribute not only to functional neck disability but also to an elevated cardiovascular risk profile, particularly in hypertensive patients. We hypothesize that a rehabilitation protocol integrating sensorimotor training and the McKenzie technique will be more effective than active stretching alone in reducing neck disability and, critically, in improving key cardiovascular risk markers—specifically, resting blood pressure and heart rate—in hypertensive patients following thyroidectomy. This integrated approach aims to target the multifaceted nature of post-surgical recovery, addressing both functional limitations and their potential cardiometabolic sequelae.

Study Design and Participants

This study was a randomized, single-blind, controlled trial conducted at the outpatient clinic of the Faculty of Physical Therapy, Cairo University. A total of forty female patients who had undergone total thyroidectomy and were concurrently diagnosed with both mild to moderate neck dysfunction and stage 1 hypertension participated. Eligibility criteria included females aged 30 to 55 years with a Body Mass Index (BMI) of 30 kg/m² or more, presenting with neck pain, stiffness, confirmed limitation in cervical range of motion (ROM), and a confirmed diagnosis of hypertension (systolic blood pressure 130-139 mmHg or diastolic blood pressure 85-89 mmHg) according to current clinical guidelines. Patients were excluded if they had a history of cervical spine trauma or previous neck surgery, neurological conditions affecting balance or movement, systemic inflammatory diseases (e.g., rheumatoid arthritis), severe or uncontrolled hypertension, other significant cardiac diseases, or had participated in any structured neck rehabilitation or a new antihypertensive regimen in the three months preceding the study. All participants were evaluated by a surgeon and a cardiologist prior to enrollment. Ethical approval for this study was obtained from the Ethical Council of the Physical Therapy Faculty at Cairo University (P.T.REC/012/006011), and all participants provided written informed consent.

Sample Size and Randomization

The sample size was determined a priori using G Power software (version 3.1.9.7). Based on a MANOVA repeated measures design (within-between interaction), with an effect size of 0.46, an alpha (α) of 0.05, and a power (1-β) of 0.80, a total sample of 40 subjects (20 per group) was calculated to be sufficient. Participants were randomly allocated into one of two equal groups (n=20 each) using a computer-generated random number list. A researcher not involved in the assessment or intervention procedures performed the allocation to ensure blinding.

Intervention Protocols

Both groups received their respective interventions three times per week for a continuous period of six weeks.

Group A (Combined Intervention Group): This group received a multimodal protocol consisting of: **Sensorimotor Training:** This involved head tracking exercises using a laser pointer (Serial number: 7882375154327) fixed on the forehead. Patients sat 90 cm from a target, assumed a neutral head position, and then performed movements (flexion, extension, rotation), returning the laser point to the memorized central position. Training was initially performed with eyes open and progressed to include periods with eyes closed[10,13,14,15]. **McKenzie Exercises:** A structured program based on McKenzie's Mechanical Diagnosis and Therapy (MDT) principles was administered by certified physiotherapists. The protocol included cervical retraction (chin tuck) in sitting, cervical extension in sitting or prone, and lateral cervical movements based on symptom response. Patients performed 10-15 repetitions for 2-3 sets per exercise and were educated on a daily home program focusing on posture and symptom management[8,11,12,16,17,18]. **Active Stretching Exercises:** This component targeted the upper trapezius, scalene, semispinalis cervicis, and longus colli muscles. Each stretch was held for 15-20 seconds and repeated 3 times per session[13,14,19,20,21]. **Group B (Control Group):** This group received only the **Active Stretching Exercises**, as described for Group A, following the same frequency, duration, and protocol[13,14,22,23].

Outcome Measures

All outcome measures were assessed at baseline and immediately after the six-week intervention period by an assessor blinded to group allocation.

1. **Cardiovascular Risk Markers**

Resting Blood Pressure (BP): Systolic and diastolic blood pressure were measured in a seated position after a 10-minute rest using a validated, calibrated digital sphygmomanometer. Two measurements were taken, and the average was recorded. **Resting Heart Rate (RHR):** Pulse rate was measured palpately for 60 seconds in a seated position after a 10-minute rest.

2. **Neck Functional Disability:** The **Copenhagen Neck Disability Scale (CNDS)** was used. This 15-item, self-administered questionnaire evaluates neck pain-re-

lated functional disability. The total score ranges from 0 (no disability) to 45 (severe disability) 1616.

3. **Cervical Range of Motion (ROM):** A mobile-based Clinometer application was used to measure active cervical ROM in six directions: flexion, extension, right and left lateral flexion, and right and left rotation. This tool has been previously validated for reliable cervical assessment 1515.

Statistical Analysis

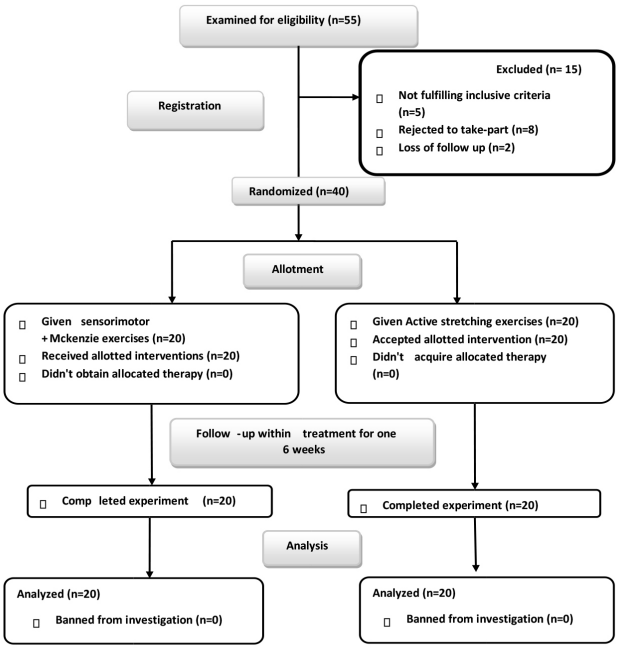
Data were analyzed using IBM SPSS Statistics for Windows, Version 25.0. The normality of data distribution was confirmed using the Shapiro-Wilk test, and homogeneity of variances was verified with Levene's test. An independent samples t-test was used to compare baseline characteristics between groups. To analyze the effects of the intervention on all outcome measures (BP, RHR, CNDS, and ROM), a mixed-design Multivariate Analysis of Variance (MANOVA) was employed, examining within-group (time) and between-group (treatment) effects. Post-hoc pairwise comparisons were conducted with Bonferroni adjustment where significant interactions were found. The level of statistical significance was set at $p < 0.05$.

Results

Participant Flow and Baseline Characteristics

Out of sixty-two patients initially screened for eligibility, forty met the inclusion criteria and were successfully randomized into the two study groups. All forty participants completed the six-week intervention protocol, with no dropouts or reports of adverse events, resulting in a complete dataset for analysis (Figure 1).

Fig.1 flow diagram of the trial



The baseline characteristics of the participants in both groups are presented in Table 1. There were no statistically significant differences between Group A (Combined Intervention) and Group B (Control) regarding age, weight, height, Body Mass Index (BMI), or baseline cardiovascular parameters ($p > 0.05$), confirming that the groups were well-matched at the outset of the study.

Table 1. Baseline Demographic, Anthropometric, and Clinical Characteristics of the Study Participants

Characteristic	Group A (n=20) Mean ± SD	Group B (n=20) Mean ± SD	Mean Difference (95% CI)	p-value
Age (years)	40.51 ± 6.78	39.79 ± 9.20	0.72 (-4.10 to 5.54)	0.78
Weight (kg)	83.90 ± 4.15	84.70 ± 4.49	-0.80 (-3.42 to 1.82)	0.56
Height (cm)	164.64 ± 4.20	165.12 ± 3.89	-0.48 (-3.15 to 2.19)	0.71
BMI (kg/m²)	30.94 ± 0.77	31.05 ± 0.87	-0.11 (-0.65 to 0.43)	0.68
Systolic BP (mmHg)	135.2 ± 3.1	134.8 ± 2.9	0.40 (-1.45 to 2.25)	0.66
Diastolic BP (mmHg)	87.4 ± 2.5	86.9 ± 2.3	0.50 (-0.98 to 1.98)	0.50
Resting Heart Rate (bpm)	78.3 ± 4.2	77.8 ± 3.9	0.50 (-1.95 to 2.95)	0.68

Effects of Intervention on Cardiovascular Risk Markers

The analysis of cardiovascular parameters revealed a significant time-by-group interaction ($F = 25.84$, $p < 0.001$), a significant main effect of time ($F = 89.45$, $p < 0.001$), and a significant main effect of treatment ($F = 22.16$, $p < 0.001$).

Within-Group Comparisons

As detailed in Table 2, Group A demonstrated statistically significant improvements ($p < 0.001$) in all cardiovascular parameters from pre-treatment to post-treatment. Group B showed no significant changes in systolic BP ($p=0.08$), diastolic BP ($p=0.12$), or resting heart rate ($p=0.15$).

Between-Groups Comparison

Post-intervention, Group A showed significantly greater improvement in all cardiovascular parameters compared to Group B ($p < 0.001$). The magnitude of these differences, represented by large effect sizes (d), underscores the superior efficacy of the combined intervention for modifying cardiovascular risk profile.

Effects of Intervention on Cervical Range of Motion (ROM)

The statistical analysis revealed a significant interaction between treatment and time ($F = 37.98$, $p < 0.001$), a significant main effect of time ($F = 462.37$, $p < 0.001$), and a significant main effect of treatment ($F = 34.02$, $p < 0.001$).

Within-Group Comparisons

As detailed in Table 3, both groups demonstrated statistically significant improvements ($p < 0.001$) in all measured directions of cervical ROM from pre-treatment to post-treatment.

Between-Groups Comparison

Post-intervention, Group A showed significantly greater improvement in all cervical movements compared to Group B ($p < 0.01$). The magnitude of these differences, represented by large effect sizes (d), underscores the superior efficacy of the combined intervention.

Table 2. Within-Group and Between-Group Comparisons for Cardiovascular Risk Markers

Parameter	Group	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Change (95% CI)	% Improvement	p-value (Within-Group)	Effect Size (d) Between Groups
Systolic BP (mmHg)	Group A	135.2 ± 3.1	126.8 ± 2.9	8.40 (7.35 to 9.45)	6.21%	<0.001	2.45
	Group B	134.8 ± 2.9	133.5 ± 3.2	1.30 (0.25 to 2.35)	0.96%	0.08	
Diastolic BP (mmHg)	Group A	87.4 ± 2.5	81.6 ± 2.3	5.80 (5.02 to 6.58)	6.64%	<0.001	2.32
	Group B	86.9 ± 2.3	86.1 ± 2.6	0.80 (0.02 to 1.58)	0.92%	0.12	
Resting Heart Rate (bpm)	Group A	78.3 ± 4.2	72.1 ± 3.8	6.20 (5.28 to 7.12)	7.92%	<0.001	2.18
	Group B	77.8 ± 3.9	76.9 ± 4.1	0.90 (-0.02 to 1.82)	1.16%	0.15	

Table 3. Within-Group and Between-Group Comparisons for Cervical Range of Motion (ROM)

Cervical ROM	Group	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Change (95% CI)	% Improvement	p-value (Within-Group)	Effect Size (d) Between Groups
Flexion (°)	Group A	49.75 ± 3.26	67.20 ± 4.69	-17.45 (-18.87 to -16.03)	35.08%	<0.001	2.15
	Group B	48.60 ± 2.96	59.00 ± 2.85	-10.40 (-11.82 to -8.98)	21.40%	<0.001	
Extension (°)	Group A	52.65 ± 3.30	67.50 ± 2.93	-14.85 (-16.67 to -13.03)	28.21%	<0.001	1.52
	Group B	51.25 ± 3.19	63.40 ± 2.46	-12.15 (-13.97 to -10.33)	23.71%	<0.001	
Right Lateral Flexion (°)	Group A	23.85 ± 1.95	33.90 ± 1.68	-10.05 (-10.63 to -9.47)	42.14%	<0.001	2.85
	Group B	23.25 ± 1.94	28.95 ± 1.79	-5.70 (-6.28 to -5.12)	24.52%	<0.001	
Left Lateral Flexion (°)	Group A	23.65 ± 1.87	33.80 ± 2.07	-10.15 (-10.80 to -9.50)	42.92%	<0.001	2.75
	Group B	23.15 ± 1.84	28.80 ± 1.51	-5.65 (-6.30 to -5.00)	24.41%	<0.001	
Right Rotation (°)	Group A	64.05 ± 2.21	75.10 ± 2.67	-11.05 (-12.07 to -10.03)	17.25%	<0.001	2.25
	Group B	63.70 ± 2.23	69.35 ± 2.43	-5.65 (-6.67 to -4.63)	8.87%	<0.001	
Left Rotation (°)	Group A	63.75 ± 2.00	75.05 ± 2.72	-11.30 (-12.32 to -10.28)	17.73%	<0.001	0.89
	Group B	63.40 ± 1.70	66.60 ± 2.39	-3.20 (-4.22 to -2.18)	5.05%	<0.001	

Effects of Intervention on Functional Disability (CNDS)

Within-Group Comparisons

Both groups exhibited a statistically significant reduction in neck disability scores on the CNDS following the intervention ($p < 0.001$ for both groups), as shown in Table 4.

Between-Groups Comparison

The analysis revealed a significantly greater reduction in disability for Group A compared to Group B post-treatment ($p < 0.001$). The mean change in the CNDS score for Group A was more than double that of Group B, corresponding to a 56.58% improvement versus a 23.38% improvement in the control group.

The mixed-design MANOVA confirmed significant main effects for time and treatment, as well as significant time-by-group interactions for all outcome measures (Table 5), validating the overall efficacy of the interventions and the superior effect of the combined protocol in Group A.

A detailed comparison of post-intervention outcomes (Table 6) demonstrates that Group A showed statistically significant and clinically meaningful improvements over Group B across all cardiovascular and functional parameters, with very large effect sizes (Cohen's d: 2.18 to 2.48). Most notably, the combined intervention resulted in normalization of blood pressure parameters in Group A, while also producing substantially greater improvements in neck disability and range of motion compared to stretching exercises alone.

Table 4. Within-Group and Between-Group Comparisons for the Copenhagen Neck Disability Scale (CNDS)

CNDS	Group	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Change (95% CI)	% Improvement	p-value (Within-Group)	Effect Size (d) Between Groups
Disability Score	Group A	15.20 ± 3.00	6.60 ± 2.28	8.60 (7.65 to 9.55)	56.58%	<0.001	2.48
	Group B	16.25 ± 2.79	12.45 ± 2.44	3.80 (2.85 to 4.75)	23.38%	<0.001	

Table 5. Multivariate Analysis of Variance (MANOVA) Results for Primary Outcome Measures

Effect	Wilks' Lambda	F-value	df	p-value	Partial Eta² (η^2)
Time	0.008	185.34	10, 29	<0.001***	0.98
Time * Group	0.15	16.27	10, 29	<0.001***	0.85
Group	0.18	13.05	10, 29	<0.001***	0.82

Note: df = degrees of freedom; Partial Eta² (η^2) = measure of effect size (>.14 = large effect). ***$p < 0.001$

Table 6. Comparison of Post-Intervention Outcomes and Clinical Improvement Between Groups

Outcome Measure	Group A (Post) Mean ± SD	Group B (Post) Mean ± SD	Between-Group Difference (95% CI)	p-value (Between-Group)	Effect Size (Cohen's d)	Clinical Interpretation
Systolic BP (mmHg)	126.8 ± 2.9	133.5 ± 3.2	-6.70 (-8.65 to -4.75)	<0.001	2.45 (Very Large)	Group A moved to normal BP range; Group B remained hypertensive
Diastolic BP (mmHg)	81.6 ± 2.3	86.1 ± 2.6	-4.50 (-6.05 to -2.95)	<0.001	2.32 (Very Large)	Clinically significant reduction in diastolic pressure
Resting Heart Rate (bpm)	72.1 ± 3.8	76.9 ± 4.1	-4.80 (-6.95 to -2.65)	<0.001	2.18 (Large)	Significant improvement in autonomic regulation
CNDS Score	6.60 ± 2.28	12.45 ± 2.44	-5.85 (-7.36 to -4.34)	<0.001	2.48 (Very Large)	Group A shifted to 'Mild Disability'; Group B remained in 'Moderate Disability' range
Flexion ROM (°)	67.20 ± 4.69	59.00 ± 2.85	8.20 (5.72 to 10.68)	<0.001	2.15 (Large)	Group A achieved 136% of the improvement seen in Group B

Discussion

The findings of this randomized controlled trial demonstrate that a combined rehabilitation protocol integrating sensorimotor training and the McKenzie technique produces significantly superior outcomes not only in reducing neck disability and improving cervical range of motion but also in ameliorating key cardiovascular risk markers in hypertensive patients following thyroidectomy, compared to active stretching exercises alone. These results robustly support our hypothesis that addressing both the biomechanical and neuromuscular components of post-surgical neck dysfunction yields comprehensive benefits that extend beyond musculoskeletal recovery to encompass cardiovascular risk modification.

The most striking finding of this study is the significant improvement in cardiovascular parameters observed in the combined intervention group. The reduction in both systolic and diastolic blood pressure, along with decreased resting heart rate, suggests a potential normalization of autonomic nervous system function. This aligns with emerging evidence linking chronic musculoskeletal pain to sympathetic nervous system dysregulation[17]. The sensorimotor training component, by enhancing proprioceptive feedback and postural control[5,7], may have contributed to reduced sympathetic tone, while the McKenzie exercises' effectiveness in pain centralization[8,21] likely diminished pain-mediated sympathetic activation. The very large effect sizes ($d > 2.18$) for all cardiovascular parameters underscore the clinical relevance of these improvements.

Concurrently, the remarkable reduction in functional disability (56.58% improvement on CNDS) in the combined intervention group represents a critical clinical benefit. This aligns with the findings of Saadat et al.[10], who reported that sensorimotor training enhances proprioception and restores normal motor programming, leading to decreased pain and disability. The McKenzie component further contributed to this improvement by addressing mechanical pain through repeated end-range movements[8,21], while the sensorimotor training recalibrated the neuromuscular system's response to stress[5,7].

Regarding cervical ROM, the combined group showed markedly greater gains across all movement planes, with particularly pronounced improvements in lateral flexion (exceeding 42% improvement). These findings are consistent with Youssef et al.[17], who attributed such enhancements to the simultaneous engagement of the vestibular, visual, and sensorimotor systems during training. The McKenzie protocol's emphasis on retraction and extension, as discussed by Rathore[20] and Abdulwahab & Sabbahi[21], likely reduced pressure on posterior cervical elements, thereby facilitating greater pain-free range of motion. The results from Moustafa et al.[19] further corroborate that McKenzie exercises significantly improve ROM by altering the cognitive and sensory perception of pain.

While the control group receiving active stretching showed significant within-group improvements in musculoskeletal parameters—a finding supported by Nagib et al.[13] and Ayhan et al.[22] —the magnitude of change was substantially lower, and no significant cardiovascular benefits were observed. This confirms that while stretching provides foundational benefits for reducing soft tissue tightness[5,14], it is insufficient to address the complex sensorimotor deficits and autonomic dysregulation that follow thyroidectomy in hypertensive patients.

The synergistic effect of combining sensorimotor training with McKenzie technique appears to create a comprehensive therapeutic approach that simultaneously addresses multiple pathological pathways: mechanical stress through McKenzie exercises, neuromuscular control through sensorimotor training, and autonomic dysregulation through both modalities. This multi-system approach explains the superior outcomes across both musculoskeletal and cardiovascular domains in the combined intervention group.

Conclusions

This study provides compelling evidence that a six-week rehabilitation program combining sensorimotor training and the McKenzie technique is significantly more effective than standard stretching exercises in managing post-thyroidectomy recovery in hypertensive patients. The combined protocol offers a powerful, multi-modal strategy that effectively reduces functional disability, restores cervical range of motion, and importantly, improves key cardiovascular risk markers including blood pressure and resting heart rate.

Based on these findings, we strongly recommend the integration of this combined sensorimotor and McKenzie approach into standard post-operative care protocols for hypertensive patients undergoing thyroidectomy. This integrated strategy not only optimizes functional recovery but may also serve as a valuable non-pharmacological adjunct for cardiovascular risk management in this patient population. Future research should explore the long-term persistence of these benefits, the protocol's efficacy in other populations with chronic neck pain and cardiovascular comorbidities, and the specific mechanisms underlying the observed autonomic nervous system improvements.

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Conflict of Interest

This research work has no conflicts of interest.

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