International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 11s, 2025
https://theaspd.com/index.php

Effect Of Kinetic Control Training On Pain And Disability In Patients With Cervical Radiculopathy

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Abstract
Background: *Cervical radiculopathy is a prevalent condition associated with neck pain, disability, postural alterations, and neuromuscular dysfunction. This study aimed to investigate the effect of a Kinetic Control (KC) training program combined with conventional physical therapy on pain intensity and neck-related disability in patients with cervical radiculopathy.* ***Design:*** *Randomized Controlled Trial.* ***Methods:*** *Sixty patients with cervical radiculopathy (aged 40–55 years) participated in this study. Participants were randomly allocated into two equal groups. The control group (n=30) received a conventional physical therapy program which included therapeutic ultrasound, Maitland mobilization, neural mobilization, isometric exercises. The study group (n=30) received the same conventional program combined with Kinetic Control training targeting uncontrolled movement patterns. Patients were assessed pre- and post-intervention for pain intensity using the Visual Analogue Scale (VAS), disability using the Neck Disability Index (NDI). The treatment protocol was administered three sessions per week for eight weeks.* ***Results:*** *There were no significant differences between the study and control groups in baseline characteristics ($p > 0.05$). Both groups showed significant post-treatment improvements in VAS and NDI scores ($p < 0.001$). However, the study group achieved significantly greater reductions in pain (VAS) and neck disability (NDI) compared to the control group ($p < 0.001$).* ***Conclusion:*** *Adding a Kinetic Control training program to conventional physical therapy significantly enhanced improvements in pain intensity and neck-related disability in patients with cervical radiculopathy. These findings support the integration of movement control-based retraining strategies in the management of cervical radiculopathy.*
Keywords:
Cervical radiculopathy; Kinetic Control; Movement control retraining; Visual Analogue Scale; Neck Disability Index.

INTRODUCTION

Cervical radiculopathy is a clinical condition characterized by pain, numbness, and motor dysfunction resulting from pathological processes affecting one or more cervical nerve roots. Commonly presenting with radiating symptoms in the upper extremity, cervical radiculopathy has become increasingly prevalent in modern clinical practice, with an annual incidence of approximately 83 per 100,000 individuals (1, 2). Various factors, including prolonged poor postures, occupational demands, sedentary lifestyles, and age-related changes, contribute to the mechanical and inflammatory processes responsible for nerve root compromise. The primary pathological mechanisms involve intervertebral disc herniation, osteophyte formation, or narrowing of the intervertebral foramen, producing neurological symptoms of varying severity depending on the duration and degree of compression (3)**.**A specific and common form of this condition is cervical spondylotic radiculopathy (CSR), which arises secondary to degenerative changes affecting the intervertebral discs, facet joints, and surrounding bony structures. As these degenerative processes advance, they lead to disc height reduction, osteophytic encroachment, and foraminal narrowing, all of which contribute to nerve root compression and the characteristic clinical symptoms of neck pain, radiating arm pain, sensory disturbances, and motor deficits (4). CSR is most frequently observed in middle-aged and elderly populations, reflecting the cumulative effects of mechanical loading and age-related degeneration on the cervical spine (5, 6).

An important postural abnormality frequently associated with cervical radiculopathy is forward head posture (FHP), characterized by anterior displacement of the head relative to the shoulders. This postural

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fault is estimated to affect a significant proportion of the population and is especially common in individuals engaged in prolonged desk work or sedentary activities (7). FHP increases mechanical stress on the cervical spine and adjacent soft tissues, reduces cervical range of motion, and contributes to muscle imbalance, with overactivity of superficial neck muscles and inhibition of deep cervical flexors. Furthermore, this postural alteration has been shown to decrease the craniovertebral angle (CVA), a clinical measure of head posture, which is often diminished in patients with cervical radiculopathy, reflecting the extent of postural dysfunction (8).Rehabilitation for cervical radiculopathy traditionally includes manual therapy, neural mobilization, and strengthening exercises. However, growing evidence suggests that interventions addressing movement coordination and motor control may offer additional benefits. Kinetic Control (KC) is one such therapeutic approach, emphasizing the identification and correction of uncontrolled movement patterns that contribute to musculoskeletal pain and dysfunction. Developed by Comerford and Mottram, KC prioritizes neuromuscular retraining of muscle recruitment, timing, and coordination over conventional strength- or flexibility-based interventions. In the cervical region, KC aims to optimize dynamic stability by improving the function muscle synergies and correcting maladaptive movement strategies (9, 10).Supporting this rationale, previous studies have highlighted alterations in muscle activity patterns, including increased activation of superficial muscles and reduced activity of deep stabilizers, in individuals with chronic neck pain and postural dysfunction (11, 12). These findings underscore the importance of movement coordination retraining in restoring functional control and reducing the mechanical stress imposed on the cervical spine during daily activities. However, limited research has specifically examined the effects of Kinetic Control training on pain and disability in patients with cervical radiculopathy.Therefore, the present study aims to investigate the effect of Kinetic Control training on pain intensity and disability in patients with cervical radiculopathy. By targeting uncontrolled movement patterns and improving neuromuscular coordination, this study seeks to determine whether Kinetic Control provides measurable clinical benefits in managing this prevalent condition.

Procedures

Participants and Randomization

This prospective, parallel group randomized clinical trial was conducted at the Outpatient Clinics of the Faculty of Physical Therapy, Cairo University, and Kasr Al-Aini Hospital. A total of 60 participants diagnosed with cervical radiculopathy were recruited. All participants were referred by a neurologist following clinical and radiological confirmation of unilateral cervical radiculopathy secondary to spondylotic changes at the lower cervical spine (C5–C6 and C6–C7 levels).

Initially, 83 individuals were screened for eligibility based on the study's inclusion and exclusion criteria. Following this process, 60 participants met the eligibility criteria and were enrolled in the study, while 23 individuals were excluded as they did not meet the required criteria. A flow diagram showing participant selection and randomization is presented in Figure 1. Participants were then randomly assigned to either the study group or the control group, with 30 participants allocated to each group, using a simple randomization method. Allocation was conducted using sequentially numbered, sealed, opaque envelopes to ensure allocation concealment.The study protocol, including procedures and ethical considerations, was approved by the Ethical Committee of the Faculty of Physical Therapy, Cairo University (Approval No. P.T.REC/012/004384). Additionally, the study was prospectively registered on ClinicalTrials.gov. under the identifier NCT06732037. All participants were provided with detailed information about the study's purpose, procedures, and management plan, and written informed consent was obtained from everyone prior to participation.

Inclusion Criteria

Patients were considered eligible for participation if they presented with unilateral cervical radiculopathy secondary to spondylotic changes at the lower cervical spine (C5–C6 and C6–C7), with duration of illness more than three months to exclude individuals in the acute inflammatory phase. Eligible patients were aged between 40 and 55 years, and both male and female participants were included. Additionally, all participants were required to have a body mass index (BMI) of less than 30 kg/m^2. To screen for forward head posture, the craniovertebral angle (CVA) was measured during the screening process using MB Ruler software, and only individuals with a CVA of less than 50° were included in the study (15).

Exclusion criteria

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Patients were excluded if they had central spinal canal stenosis, rheumatoid arthritis, a history of prior cervicothoracic spine surgery, or vertebrobasilar insufficiency. Additionally, patients were excluded if they exhibited thoracic outlet syndrome, carpal tunnel syndrome, or structural spinal instability such as spondylolisthesis. Individuals with systemic diseases including cardiovascular, infectious, or metabolic disorders that could interfere with exercise participation were also excluded. Furthermore, patients with spinal tumours were not considered for participation in this study.

Instrumentations

Assessments were conducted at baseline and after 8 weeks of intervention. The following validated tools were employed to evaluate clinical outcomes:

- **Pain Intensity**: Pain intensity was measured using the **Visual Analogue Scale (VAS)**, a valid and reliable tool for assessing pain severity (13). Participants were asked to rate their current pain intensity on a 10-centimeter horizontal line, with endpoints representing "no pain" (0) and "worst imaginable pain" (10).
- **Neck Disability**: Neck-related disability was assessed via Arabic version of the Neck Disability Index (NDI) (14). This patient-reported questionnaire consists of 10 items addressing key functional domains. Each item is scored on a 6-point ordinal scale ranging from 0 (no disability) to 5 (complete disability), resulting a maximum total score of 50.

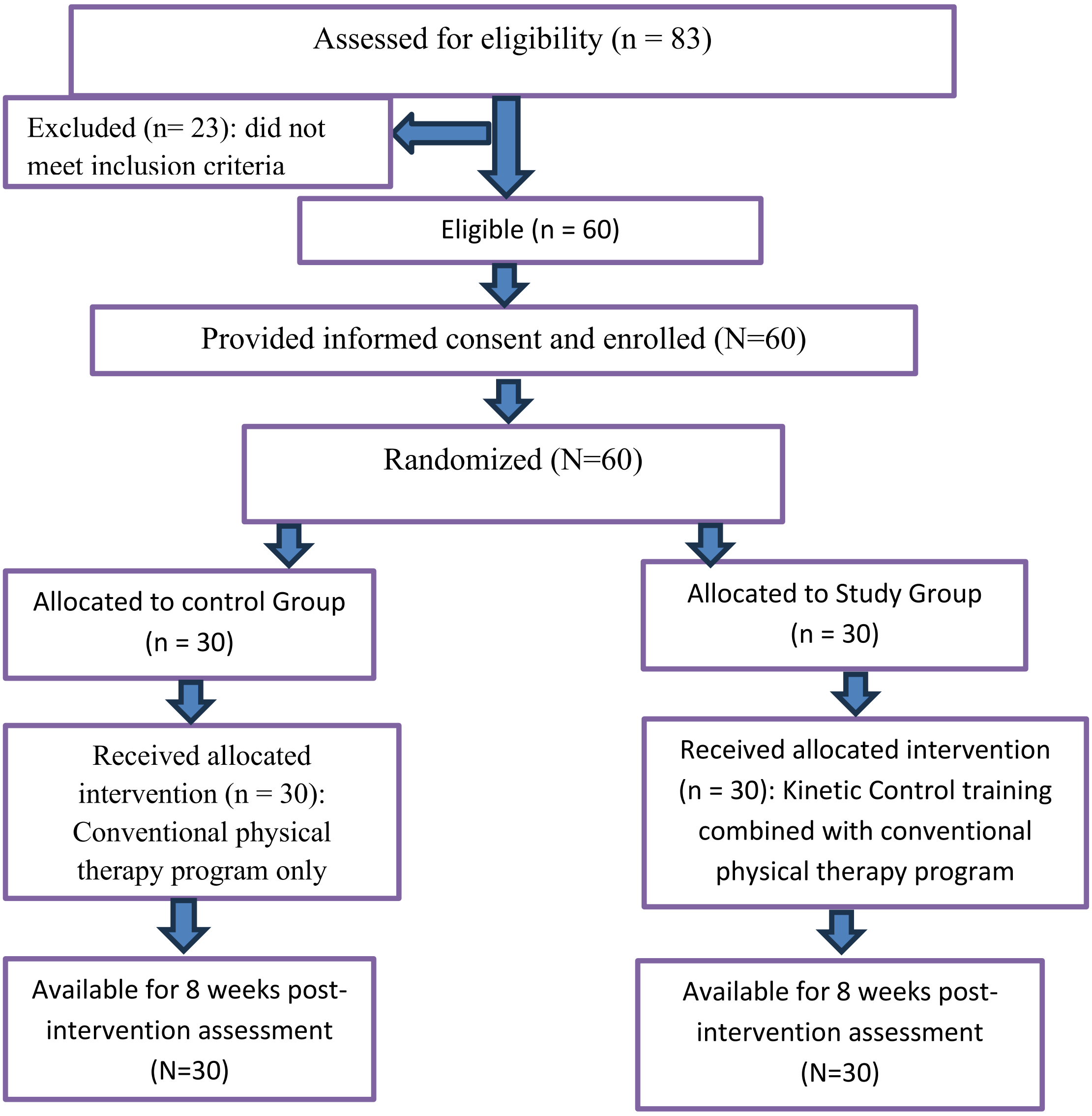

Fig (1): Flow chart of patient`s participation in the study.

Intervention

Both groups received a conventional physical therapy program designed to alleviate pain, reduce muscle tension, and enhance cervical mobility. This program included therapeutic ultrasound applied to the paravertebral muscles at a frequency of 1 MHz and an intensity of 1.5 W/cm² for five minutes in continuous mode. Maitland mobilizations (Grades III and IV) were then performed based on clinical examination findings to target hypomobile segments (16). Additionally, median nerve neural mobilization was administered using the sliding technique for 10 repetitions, each held for 3 seconds (17). Neck isometric exercises were also prescribed, involving resisted isometric contractions in multiple directions, each held for 5 seconds and repeated 10 times (18).The treatment program was scheduled for three sessions per week over a period of eight weeks, with each session lasting approximately 60 minutes.In addition to the conventional physical therapy program, the study group received a Kinetic Control (KC) training program targeting uncontrolled movement patterns identified through baseline movement control assessments. These assessments determined the site and direction of uncontrolled movement at the cervical, scapular, and glenohumeral regions, guiding the selection of individualized retraining exercises.The Kinetic Control program incorporated patient education regarding their uncontrolled movement, retraining of movement direction control, and muscle synergy retraining. Coordination retraining was performed using the specific test movements identified during assessment, with increased repetitions to reinforce correct movement patterns and restore control in the specific dysfunctional direction.This program began with patient education on movement dysfunction and the importance of maintaining a neutral posture during functional activities. Retraining exercises focused on correcting specific uncontrolled movement patterns, including lower cervical flexion, upper cervical extension, mid-cervical hinging, side-bending, rotation, and scapulothoracic glenohumeral control. For instance, lower cervical flexion UCM correction involved positioning both the upper and lower cervical spine in neutral with the head supported, instructing the patient to perform upper cervical flexion (nodding) independently without compensatory lower cervical flexion. As control improved, external support was gradually withdrawn and the complexity of the task increased. To address scapulothoracic and glenohumeral dysfunction, retraining exercises included performing shoulder flexion in standing with the scapula supported against a wall and the elbow flexed to reduce load, while using self-palpation for feedback. Progression involved gradually increasing the flexion range, extending the elbow, and ultimately performing the full range of motion without compensatory scapular movement or glenohumeral translation. Visual, auditory, and kinaesthetic cues were incorporated throughout to enhance movement control and reinforce correct patterns (9).The KC protocol emphasized optimizing muscle recruitment patterns by promoting deep stabilizer activation and minimizing overactivity of superficial muscles. Exercises involved low-load, cognitively directed movements in the identified uncontrolled direction, progressing from non-weight-bearing to functional positions (9, 19, 20, 21).

Statistical analysis.

Unpaired t-test was conducted for comparison of subject characteristics between groups and Chi- squared test was used for comparison of sex distribution. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to test the homogeneity between groups. Mixed MANOVA was performed to compare within and between groups effects on VAS, NDI. Bonferroni corrections were carried out for subsequent multiple comparisons. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analysis was conducted through the statistical package for social sciences (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

***- Subject characteristics*:**

Table (1) shows the subject characteristics of control and study groups. There was no significant difference between groups in age, BMI, and sex distribution ($p > 0.05$).

Table 1. Comparison of subject characteristics between control and study groups:

	Control group	Study group	p-value
	Mean ± SD	Mean ± SD	
Age (years)	47.97 ± 3.74	47.93 ± 3.22	0.97

BMI (kg/m²)	25.38 ± 1.80	24.83 ± 1.97	0.26
Sex, n (%)			
Females	13 (43%)	11 (37%)	0.59
Males	17 (57%)	19 (63%)	

SD, Standard deviation; p value, Level of significance.

Effect of treatment on VAS, NDI:

Mixed MANOVA revealed that there was a significant interaction of treatment and time (F = 74.93, p = 0.001, Partial Eta Squared = 0.85). There was a significant main effect of time (F = 733.36, p = 0.001, Partial Eta Squared = 0.98). There was a significant main effect of treatment (F = 12.85, p = 0.001, Partial Eta Squared = 0.48).

Within group comparison

Post-treatment, both the study and control groups showed a significant decrease in VAS and NDI ($p < 0.001$) (Table 2).

Between group comparison

Comparison between groups post-treatment revealed a significant decrease in VAS (d = 5.62, $p < 0.001$) and NDI (d = 3.46, $p < 0.001$) (Table 2).

Table 2. Mean VAS and NDI pre and post treatment of control and study groups:

	Pretreatment	**Post treatment**			
	Mean ±SD	**Mean ±SD**	**MD**	**95% CI**	**p value**
VAS					
Control group	8.43 ± 0.94	5.57 ± 1.28	2.86	2.49: 3.24	0.001
Study group	8.67 ± 0.76	3.13 ± 1.17	5.54	5.16: 5.91	0.001
MD	-0.24	2.44			
95% CI	-0.67: 0.21	1.80: 3.07			
	p = 0.29	***p = 0.001***			
Effect size		***5.62***			
NDI					
Control group	25.07 ± 5.16	16.13 ± 3.62	8.94	7.87: 10.00	0.001
Study group	23.43 ± 4.97	9.33 ± 2.93	14.10	13.03: 15.17	0.001
MD	1.64	6.80			
95% CI	-0.98: 4.25	5.10: 8.50			
	p = 0.22	***p = 0.001***			
Effect size		***3.46***			

SD, Standard deviation; MD, Mean difference; p value, Probability value

DISCUSSION:

The present study was conducted to investigate the effect of Kinetic Control training on pain and disability in patients with cervical radiculopathy. The findings revealed significant improvements in both groups across all measured outcomes, with significantly greater improvements in the Kinetic Control group. These results underscore the added value of incorporating movement control and targeted muscle synergy retraining alongside conventional physical therapy interventions in the management of cervical radiculopathy.Consistent with previous literature, both groups exhibited significant within-group reductions in pain intensity and neck-related disability following the intervention period. These findings align with those of Sadeghi et al. who confirmed that isometric exercises significantly reduce pain and disability in patients with cervical spondylosis, reporting notable improvements in (NDI) following four weeks of training (22). Further supporting these findings, a study by Alshami and Bamhair involving vertebral mobilization alongside exercises showed significant improvements in pain and neck disability, reinforcing the effectiveness of combined treatment strategies (23).The observed reductions are likely attributable to the neuromodulatory effects of therapeutic interventions, including mobilizations, and exercises, which stimulate local afferent input and activate descending inhibitory pathways, modulating pain perception through central mechanisms (24, 25). Additionally, it has been proposed that muscle contractions induced by therapeutic exercises stimulate mechanoreceptors including muscle spindles, Golgi tendon organs, and joint proprioceptors, promoting the release of endogenous opioids and endorphins, contributing to exercise-induced hypoalgesia (26, 27). These peripheral mechanisms likely complemented the central neuromodulatory effects, collectively supporting the reductions in pain intensity and disability observed in both groups following the intervention period.However, between-group comparisons in the current study revealed that the addition of Kinetic Control training produced significantly greater reductions in VAS and NDI scores compared to conventional therapy alone. These findings are consistent with those reported by Jull et al., who demonstrated that while both conventional and motor control-based interventions effectively reduce neck pain and disability, only those specifically addressing movement coordination impairments result in meaningful improvements in postural alignment and muscle recruitment patterns (28). While exercise interventions are broadly known to produce systemic hypoalgesic effects and enhance proprioceptive feedback, the individualized, movement-specific retraining embedded within the Kinetic Control framework provides an additional therapeutic mechanism. By classifying uncontrolled movement by site and direction, this approach facilitates precise exercise prescription and correction of motor control deficits responsible for persistent nociceptive input and functional limitation (9). These principles were reflected in the present study, with the study group experiencing greater reductions in pain and disability. While some previous studies have reported conflicting findings regarding the association between forward head posture and neck pain, such discrepancies may be attributed to methodological variations (29, 30). In contrast, experimental studies focusing on corrective interventions, such as the one conducted by Diab and Moustafa, demonstrate that adding postural correction exercises to standard modalities achieved superior and sustained symptom relief in patients with cervical spondylotic radiculopathy (31).The sustained postural imbalance and neuromuscular dysfunction often observed in cervical radiculopathy are believed to perpetuate nociceptive input and functional limitation. The findings of the current study suggest that the greater pain and disability reductions observed in the Kinetic Control group are likely attributable to the targeted restoration of normal movement coordination and muscle synergy, as advocated by Comerford and Mottram (9). By correcting uncontrolled movements and addressing associated muscle recruitment faults, this approach likely mitigates the mechanical stresses contributing to pain and recurrent dysfunction.

Additional evidence has highlighted the clinical value of motor control interventions. Zaworski et al. demonstrated that incorporating Kinetic Control-based motor control training into conventional rehabilitation significantly reduced lumbar spine pain and disability compared to standard training alone in female football players (32). Complementing these findings, Abo Alfa et al. compared the effects of the Kinetic Control concept with Mulligan mobilization in patients with low back pain and radiculopathy. Both groups exhibited significant improvements in functional disability and pain intensity, with the Kinetic Control group achieving superior outcomes (33). These findings emphasize the value of targeted motor control retraining in managing radiculopathy-associated musculoskeletal dysfunctions across spinal regions and support the current study’s demonstration of its efficacy in cervical radiculopathy.

Akhtar et al. similarly identified greater improvements pain outcomes with motor control exercises compared to general exercise programs, suggesting that the targeted nature of motor control interventions contributes to their superior efficacy in addressing underlying neuromuscular dysfunctions associated with persistent pain (34). Conversely, studies by Macedo et al., Ferreira et al., and Shamsi et al. did not observe significant differences between motor control and general fitness exercises, reflecting ongoing debate regarding their relative benefits (35,36,37). However, Saragiotto et al.’s meta-analysis concluded that motor control training is at least as effective as other exercise modalities in managing spinal pain, with several studies demonstrating its specific advantages in reducing disability (38).

CONCLUSION

Kinetic Control training combined with conventional physical therapy produced superior improvements in pain, disability outcomes in patients with cervical radiculopathy compared to conventional therapy alone.Future research involving larger sample sizes, long-term follow-up, and exploration of additional functional and postural outcomes is warranted to further substantiate the role of kinetic control training in the comprehensive management of cervical spine disorders.

Conflicts of interest

The author(s) asserted no conflicts of interest regard to the study, authorship, and/or publication of this study.

Funding Sources

This research did not receive any specific donation from funding agencies.

Acknowledgments

The author would like to thank all the participants who generously contributed their time and effort to this study. Special appreciation is also extended to the clinical and academic staff whose support and guidance were invaluable throughout the research process.

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