

# Comparative Effectiveness of Neuromuscular Electrical Stimulation Versus Isometric Exercises in Patients with Cervicogenic Headache: A Randomized Controlled Trial

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**Abstract:** **Background:** Cervicogenic Headache (CGH) is a secondary headache disorder in which pain is referred from the cervical spine. It is characterized by unilateral headache, restricted cervical range of motion, and pain aggravated by neck movement or awkward posture. Dysfunction of the upper cervical joints (C0-C3), weakness of the Deep Neck Flexors (DNF), and tight cervical extensors are common causes. Isometric exercises are considered the gold standard for strengthening deep cervical flexors without excessive stress on cervical joints. These low-load endurance exercises restore normal muscle function. Neuromuscular Electrical Stimulation (NMES) uses electrical currents to produce muscle contractions. It is believed to re-educate weak muscles, reduce spasm in tight extensors such as the upper trapezius, and decrease pain through the Gate Control Theory. **Aim:** To compare the therapeutic efficacy of NMES and isometric exercises in managing Cervicogenic Headache. **Objective:** To compare the effects of neuromuscular electrical stimulation and isometric exercises on pain, disability, and cervical mobility in patients with cervicogenic headache. **Methods:** Forty-six participants with cervicogenic headache were allocated into two groups. One group received NMES, while the other performed supervised isometric cervical exercises. **Outcomes included** Numeric Pain Rating Scale, Neck Disability Index, and Cervical Flexion Rotation Test before and after intervention. **Results:** Both groups improved significantly. The NMES group demonstrated greater reductions in pain and disability, while between-group differences in cervical mobility was not statistically significant. **Conclusion:** Both interventions were beneficial; NMES showed superior improvement in selected outcomes within study limitations.

**Keywords:** Cervicogenic headache; neuromuscular electrical stimulation; isometric exercise; neck disability index; cervical flexion rotation test; physiotherapy rehabilitation; neck pain

## 1. Introduction

Cervicogenic headache (CGH) is a secondary headache disorder characterized by strictly unilateral head pain originating from structural or anatomical dysfunctions within the cervical spine [1]. This referred pain is mediated by the convergence of cervical and trigeminal afferents within the trigeminocervical nucleus [2]. The pathomechanics of CGH are strongly linked to altered cervicocephalic kinesthesia, notably presenting as delayed feed-forward activation and profound weakness in the deep neck flexors (DNF) [3]. Sustained biomechanical stress and postural deviations frequently exacerbate these underlying musculoskeletal dysfunctions, increasing the risk of symptom onset.

The gold standard for the conservative management of CGH relies on active physiotherapeutic rehabilitation. Targeted, low-load isometric endurance training for the craniocervical flexors has consistently proven superior to passive modalities in significantly reducing both headache intensity and frequency by restoring normal muscle function [4, 5]. However, chronic pain and consequent protective muscle guarding frequently restrict a patient's ability to achieve optimal voluntary muscle contractions during early rehabilitation.

To address this limitation, electrotherapy modalities such as Neuromuscular Electrical Stimulation (NMES) are often integrated to provide crucial short-term pain relief and

facilitate early neuromuscular re-education [6]. This sensory analgesia creates a vital "analgesic window," modulating nociceptive input so patients can perform active movements with greater tolerance [7]. While the independent benefits of static isometric stabilization and electrical stimulation are well-documented, direct comparative evaluations of their efficacy as distinct therapeutic approaches remain limited [8]. Therefore, the primary objective of this study is to compare the therapeutic efficacy of NMES versus static isometric neck exercises on pain modulation, cervical range of motion, and functional disability in individuals suffering from Cervicogenic Headache.

## 2. Methodology

**Study design:** Randomized Control Trial

**Study area:** Physiotherapy OPD, Narayana Hrudayalaya health city, Bangalore.

**Study Duration:** 3 months

**Study population:** Patients diagnosed with cervicogenic headache.

**Sampling:** Simple random Sampling

**Sample size (with justification):** Total sample size = 46

**Eligibility Criteria and Participants recruitment procedure:**

**Inclusion Criteria:**

- Individuals aged 20–50 years diagnosed with cervicogenic headache (CGH) based on the International Classification of Headache Disorders (ICHD-3).
- Chronic CGH (>3 months).
- Moderate to severe pain (Cervical Headache Index  $\geq 5$ ).
- No neurological deficits.

**Exclusion Criteria:**

- History of cervical spine surgery.
- Active infections or skin conditions at the electrode site.
- Pregnancy.
- Uncontrolled hypertension or cardiovascular disease

**3. Procedure**

Subjects who fulfilled the eligibility criteria and were willing to participate in the study were recruited for the study. Using Simple random sampling through computer-generated tables the subjects were allocated into Group 1 and Group 2

Informed Consent was obtained from the participant before the onset of the study  
Techniques applied in the study were of standard care.

**Group I:**

This group received NMES.  
The NMES Technique was given 3 days per week for 6 weeks.  
The outcome measures of NPRS, CFRT and NDI were assessed before and after the treatment.

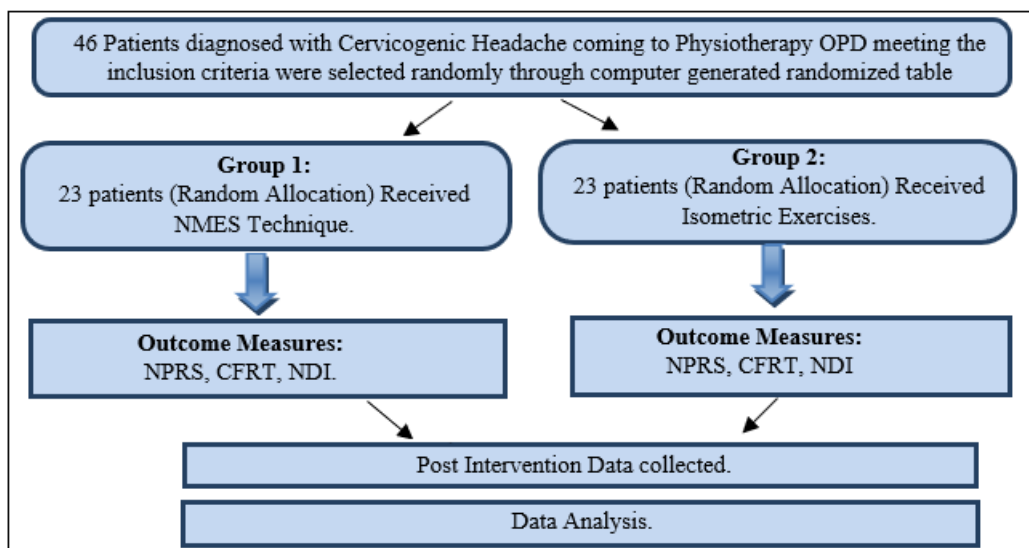
**Group II:**

This group was given Isometric exercises.  
The exercises was performed 3 times per week for 6 weeks.  
The outcome measures of NPRS, CFRT and NDI were assessed before and after the treatment

**Instrument & Tool for Data Collection:**

- **NDI:** Assess functional disability.
- **CFRT:** Assess movement at upper cervical spine.
- **NPRS:** Measures patient’s pain intensity

**Flow of Participants:**



**Data Analysis**

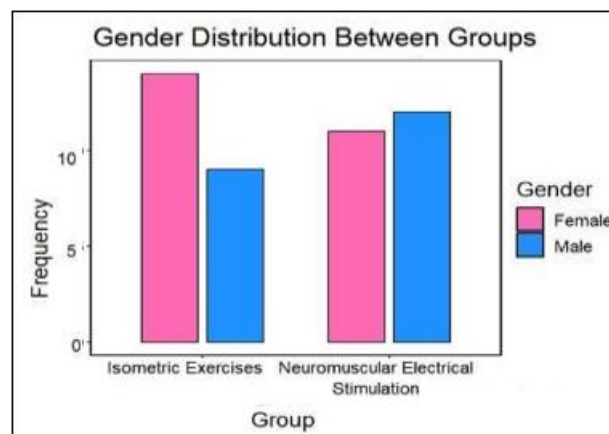
The pre-test and post-test values were analyzed and the data was managed by word 2011 and analyzed by using SPSS Version 27. Shapiro -Wilk Test was used for the Normality Test. For within the group Wilcoxon Signed Rank Test was used and for between the groups comparison Mann-Whitney U test was used for statistical analysis

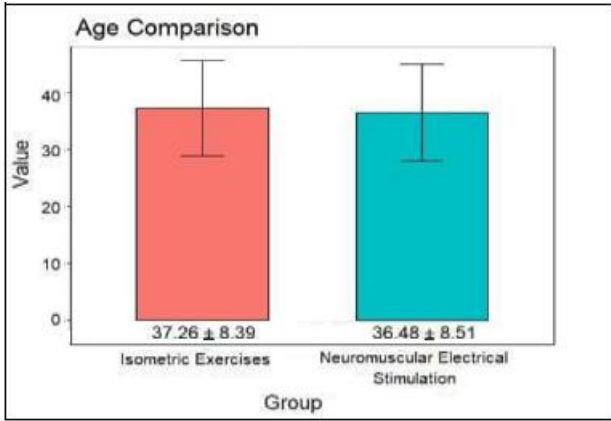
**Table 1:** Descriptive/ Demographic Statistics

S. No	Parameter	Group 1 (n=23)	Group 2 (n=23)
1	<b>Gender</b>		
	Female	11 (47.83%)	14 (60.87%)
	Male	12 (52.17%)	9(39.13%)
2	<b>Age</b>	37.26 ± 8.39	36.48 ± 8.51

The Mean Age of population for Group 1 is 37.26± 8.39 and for Group 2 is 36.48 ±8.51. Group 1 had 47.83% Females and 52.17% Males. Whereas Group 2 had 60.87% females and 39.13% Males.

**Graph 1 & 2: Gender & Age Distribution Graph:**





Graphs 1 and 2 collectively establish the baseline homogeneity of the study's cohorts, confirming a balanced distribution of gender (25 females, 21 males) and equivalent mean ages (NMES: 36.48 ± 8.51 years; Isometric: 37.26 ± 8.39 years) across both groups. This demographic equivalence (p = 0.76) is clinically crucial, as it ensures that natural variations in tissue healing rates, inherent muscle mass, and age-related cervical degeneration do not confound the therapeutic outcomes, successfully isolating the specific interventions as the primary drivers of clinical change

Table 2: Within Group Comparison between Group 1 and Group 2

Pair	Pre	Post	Mean Difference	P value
<b>NEUROMUSCULAR ELECTRICAL STIMULATION</b>				
PAIR 1 (NPRS)	6.74 ± 1.01	2.00 ± 0.74	-4.74 ± 0.54	<0.001*
PAIR 2 (CFRT)	20.13 ± 4.40	36.91 ± 3.69	16.78 ± 2.00	<0.001*
Pair	Pre	Post	Mean Difference	P value
PAIR 3 (NDI)	43.00 ± 7.90	17.78 ± 4.74	-25.22 ± 3.29	<0.001*
<b>ISOMETRIC EXERCISES</b>				
PAIR 4 (NPRS)	6.74 ± 1.01	3.04 ± 0.77	-3.70 ± 0.47	<0.001*
PAIR 5 (CFRT)	20.52 ± 4.56	34.74 ± 4.30	14.22 ± 1.17	<0.001*
PAIR 6 (NDI)	42.78 ± 7.66	25.26 ± 5.59	-17.52 ± 2.19	<0.001*

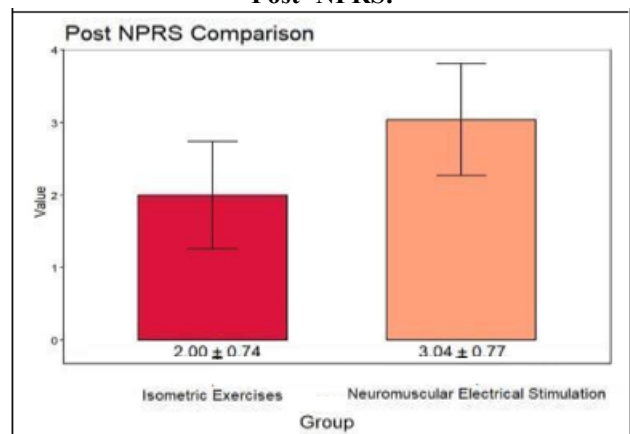
Statistical Software: SPSS Version 27; Normality Test: Shapiro -Wilk Test; Statistical Test: Wilcoxon Signed Rank Test; P value <0.05 – Significant\*

Table 3: Between Group Comparison:

Variable	Neuromuscular Electrical Stimulation (N=23)	Isometric Exercises (N=23)	P value
AGE	36.48 ± 8.51	37.26 ± 8.39	0.76
PRE-NPRS	6.74 ± 1.01	6.74 ± 1.01	1
POST-NPRS	3.04 ± 0.77	2 ± 0.74	<0.001*
PRE-CFRT	20.52 ± 4.56	20.13 ± 4.4	0.77
POST-CFRT	34.74 ± 4.3	36.91 ± 3.69	0.07
PRE-NDI	42.78 ± 7.66	43 ± 7.9	0.92
POST-NDI	25.26 ± 5.59	17.78 ± 4.74	<0.001*

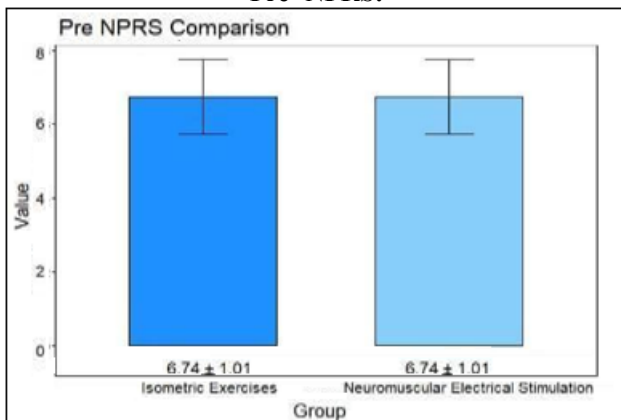
Statistical Software: R programming Software version 27, Statistical Test: Independent T test, MannWhitney U test, Normality Test: Shapiro-Wilk Test, P value <0.05 – Significant\*

Post- NPRS:



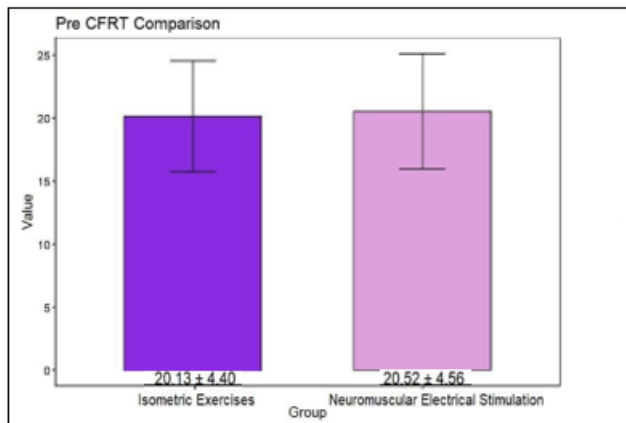
Graph 3 & 4: Comparison of Pre Test and Post Test Mean Values ± Standard Deviation of Numerical Pain Rating Scale (NPRS) for Group 1 and Group 2

Pre- NPRS:

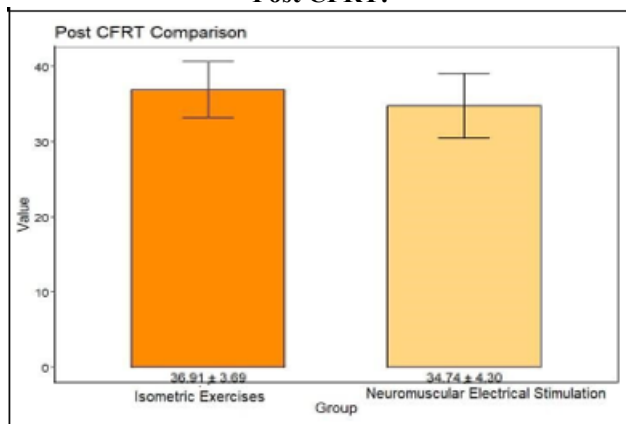


Graphs 3 and 4 illustrate the comparative efficacy of both modalities in modulating nociceptive input, with both groups starting at an identical baseline pain intensity (Pre-NPRS: 6.74). Post-intervention analysis reveals that while both approaches successfully disrupted the pain cycle, the NMES cohort demonstrated a clinically superior analgesic effect, achieving a significantly lower pain score (2.00 ± 0.74) compared to the active isometric group (3.04 ± 0.77). This supports the premise that external electrical stimulation provides a more profound and immediate sensory analgesia than voluntary muscle contractions during the early, highly symptomatic stages of rehabilitation.

Pre- CFRT:



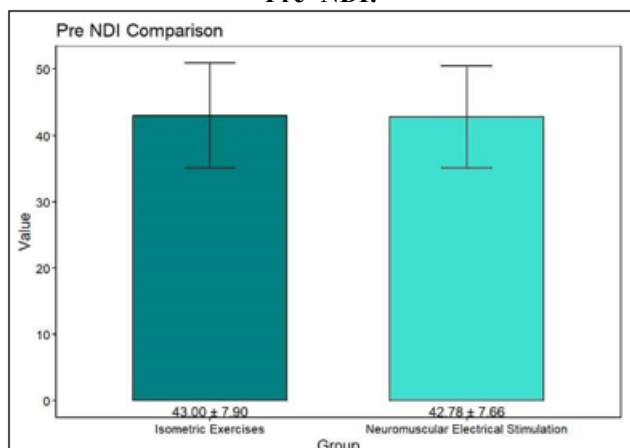
Post CFRT:



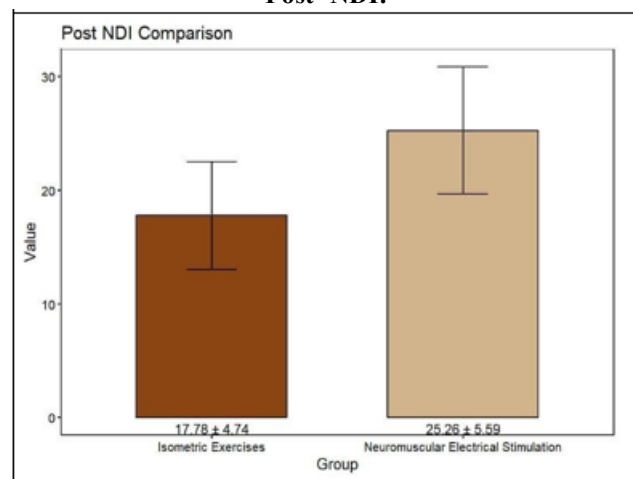
Graph 5 & 6: Comparison of Pre Test and Post Test Mean Values ± Standard Deviation of Cervical Flexion Rotation Test (CFRT) For Group 1 and Group 2

Graphs 5 and 6 compare the restoration of upper cervical kinematics, particularly C1-C2 rotation, between the two groups. Starting from comparable baseline restrictions, both therapeutic approaches yielded substantial improvements; however, NMES facilitated slightly more accelerated gains in mobility (Post- CFRT:  $36.91 \pm 3.69$ ) compared to static isometric stabilization (Post-CFRT:  $34.74 \pm 4.30$ ). This indicates that addressing deep neck flexor dysfunction through electro-motor recruitment may reduce localized biomechanical stiffness more efficiently than voluntary load-bearing exercises alone

Pre- NDI:



Post- NDI:



Graph 7 & 8: Comparison of Pre Test and Post Test Mean Values ± Standard Deviation of Neck Disability Index (NDI) For Group 1 and Group 2

Graphs 7 and 8 highlight the functional return to activities of daily living, demonstrating drastic reductions in disability scores across both cohorts from statistically similar baselines. The more pronounced recovery trend observed in the NMES cohort (Post-NDI:  $17.78 \pm 4.74$ ) compared to the isometric group (Post-NDI:  $25.26 \pm 5.59$ ) underscores its specific clinical utility. By bypassing volitional muscle inhibition, NMES allows patients to overcome protective muscle guarding earlier, translating to a faster recovery of functional independence.

#### 4. Results

The results of the present study demonstrate that both groups were comparable at baseline, as there were no statistically significant differences observed in age ( $p = 0.76$ ), pre-intervention pain scores (PRE-NPRS,  $p = 1.00$ ), cervical range of motion (PRE-CFRT,  $p = 0.77$ ), and disability levels (PRE-NDI,  $p = 0.92$ ), indicating homogeneity between the groups prior to intervention. Following the intervention, statistically significant differences were observed between the groups in post-intervention pain (POST-NPRS,  $p < 0.001$ ) and disability (POSTNDI,  $p < 0.001$ ), with the group receiving neuromuscular electrical stimulation showing better outcomes, whereas the difference in post-intervention cervical range of motion (POST-CFRT,  $p = 0.07$ ) did not reach statistical significance despite higher mean values in the NMES group. Within-group analysis revealed that both interventions produced statistically significant improvements across all outcome measures. In the neuromuscular electrical stimulation group, pain scores reduced significantly from  $6.74 \pm 1.01$  to  $2.00 \pm 0.74$ , cervical rotation improved from  $20.13 \pm 4.40$  to  $36.91 \pm 3.69$ , and disability scores decreased from  $43.00 \pm 7.90$  to  $17.78 \pm 4.74$ , all with  $p < 0.001$ . Similarly, in the isometric exercise group, pain reduced from  $6.74 \pm 1.01$  to  $3.04 \pm 0.77$ , cervical rotation improved from  $20.52 \pm 4.56$  to  $34.74 \pm 4.30$ , and disability decreased from  $42.78 \pm 7.66$  to  $25.26 \pm 5.59$ , with all changes being statistically significant ( $p < 0.001$ ). On comparing the extent of improvement between the groups, the neuromuscular electrical stimulation group demonstrated greater reductions in pain and disability, as well as a greater increase in cervical

rotation, compared to the isometric exercise group. Overall, while both interventions were effective, neuromuscular electrical stimulation was more beneficial for improving clinical outcomes.

A study conducted by Korkmaz et al. was a randomized controlled study investigating whether there are additional benefits to applying neuromuscular electrical stimulation simultaneously to exercise in chronic neck pain. The study demonstrated superior improvements in pain intensity and cervical rotation range of motion compared to exercise alone, suggesting NMES enhances muscle recruitment. These findings are consistent with the results of the present study, where the NMES group showed significantly greater reductions in pain (NPRS) and disability (NDI) compared to the isometric exercise group, supporting the enhanced effectiveness of NMES in managing Cervicogenic Headache [8].

A study conducted by Jull et al. was a randomized controlled trial comparing exercise and manipulative therapy for cervicogenic headache. The study demonstrated that a 6-week program of specific low-load endurance and isometric exercises for the craniocervical flexors significantly reduced headache frequency and intensity. The use of specific active exercises facilitated the retraining of cervical muscle function and improved overall joint stability. These findings are consistent with the present study, which also observed significant within-group improvements in pain levels and cervical range of motion following the 6-week isometric exercise intervention [4].

A study conducted by Ylinen et al. was a randomized controlled trial to evaluate the effect of neck exercises, specifically comparing strength training, endurance training, and stretching, on cervicogenic headache. The study demonstrated that both strength (isometric) and endurance training decreased neck pain and headache symptoms significantly more than stretching alone. Active neck muscle training enhances proprioceptive drive and muscular support. These findings support the results of the present study, further highlighting the effectiveness of active isometric strengthening as a viable treatment option for reducing disability in patients with CGH [5].

A study conducted by Malik and Shah compared electrical stimulation techniques toward pain levels in non-specific neck pain patients. They emphasized that the application of electrical currents modulates nociceptive input and provides significant short-term pain relief. Through the principle of sensory analgesia, electrical stimulation allows patients to perform subsequent functional activities with greater ease. These principles support the findings of the present study, explaining why the group receiving NMES achieved a significantly lower post-intervention mean pain score ( $2.00 \pm 0.74$ ) compared to the isometric group ( $3.04 \pm 0.77$ ) [7].

A study conducted by Kaviya et al. was a comparative study evaluating the short-term efficacy of static isometric neck exercises versus cervical muscle stretch among college students with cervicogenic headache. The findings suggest that static isometric exercises are a feasible and effective therapeutic approach. These results are consistent with the

present study, where both the isometric exercise group and the NMES group achieved significant increases in cervical flexion-rotation test scores (CFRT), further supporting the role of these techniques in restoring cervical mobility [9].

## 5. Conclusion

- Both NMES and isometric exercises significantly improved pain, disability, and cervical mobility in patients with cervicogenic headache. NMES demonstrated greater improvement in pain and disability outcomes in this sample. However, given methodological limitations and small sample size, larger controlled studies are needed before confirming clear clinical superiority.
- The Neuromuscular Electrical Stimulation technique is comparatively better than Isometric Exercises for improving clinical outcomes in patients presenting with cervical pain and disability

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