EFFICACY OF PROPRIOCEPTIVE TRAINING PARADIGM ON CERVICAL RADICULOPATHY

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Abstract

Background: Cervical radiculopathy (CR) is a frequent cause of axial pains seen in the neck and arms. The symptoms radiate from the neck to the arms and hands. Both acute disc herniation and chronic spondylosis, may lead to symptoms of nerve root impingement.
Aim of study: to examine the impact of proprioceptive training paradigm in cervical radiculopathy patients.
Subjects: Thirty Patients (8 males and 22 females) with unilateral chronic cervical radiculopathy. The duration of symptoms was more than six months. Their ages ranged from 35 to 55 years.
Method of allocation: They were randomized into one of two groups utilizing a secure method of opaque closed envelopes that was assigned as group A (study) and group B (control). The study group (A) 15 Patients (3 males and 12 females) received proprioception training paradigm for 30 minutes as well as a specific physiotherapy program for 30 minutes and the control group (B) 15 Patients (5 males and 10 females) received only the same specific physiotherapy program for 60 minutes.
Duration of treatment: was 3 sessions per week, for 4 weeks.
Methods: Each patient of both groups was evaluated by visual analogue scale (VAS) to measure pain intensity and CROM device to assess cervical range of motion before and after four weeks of treatment.
Results: In the present study there was a statistically significant improvement of the mean values of the cervical ROM. Moreover, there was a statistically significant reduction of the mean values of VAS in the study group when compared to the control group post treatment.
Conclusion: proprioception training paradigm has a significant impact on improving cervical range of motion and decreasing pain in cervical radiculopathy patients.

Keywords: Cervical Radiculopathy, Proprioception Training Paradigm and Selected Physical Therapy Program

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1. INTRODUCTION

Cervical radiculopathy (CR), caused by disc herniation, cervical spondylosis, or both, is a pain radiating along the distribution of a cervical nerve root that can be (1). Degenerative changes in the cervical vertebrae that occur with aging are all referred to as cervical spondylosis (CS). Degeneration can impact the soft tissues that support the spine, including the intervertebral discs, facet joints, uncovertebral joints, as well as soft tissues. In its early stages CS is frequently asymptomatic (2).
Symptomatic CS patients are frequently classified into three clinical syndromes: axial neck pain, cervical radiculopathy, or degenerative cervical myelopathy. Axial neck pain is defined as discomfort that runs down the cervical spine and paraspinal muscles (3). Annual CR incidence rates have been estimated to range from 63.50 to 107.30 per 100,000 individuals. The location of radiculopathy is determined by which nerve root is damaged (4).
The most common symptoms of cervical degenerative radiculopathy are neck pain and unpleasant neck muscle spasms, as well as paresthesia, numbness, or weakness from the shoulder or upper back to the upper arm, which sometimes but not always correspond to dermatomal distributions of the affected nerve root (5).
Cervical radiculopathy in rare case can caused by disc herniation, bone spurs, trauma, osteoarthritis, malignancy, or diabetes. Important risk factors for

radiculopathy are aging, racial and genetic factors, poor posture, and spinal abnormalities (6).

The incidence of Cervical spondylotic radiculopathy (CSR) occurs in about 1.79 per 1000 individuals each year; patients are often between the ages of 30 and 50; and, as a result of lifestyle changes, the prevalence of cervical spondylitis shows a tendency of being younger and grows annually (7).

Female patients exhibit higher active ROM than men, except in flexion but the differences are minor. The possible range diminishes with age, with the exception of rotation at C1-C2 that could increase.

Cervical spine active motions include flexion (80 to 90), extension (70), side or lateral flexion (20 to 45), and rotation (70 to 90) right and left (8).

Cervical proprioception is essential for spatial orientation of knowing where the head is in space and how it moves in relation to the trunk. This characteristic is essential for precise visual and vestibular data processing. The sense of cervical proprioception allows you to detect the head's position in relation to your body (9). Proprioception is also crucial for making intersegmental motions that are corrective, coordinated, and goal-directed. But "cervicogenic dizziness" is still controversial due to the absence of appropriate clinical testing and uncertainty of the effect of disrupted neck proprioception on spatial orientation (10).

2. SUBJECT AND METHODS

- **Study design**

True experimental research design study (pre-test and post-test control group design) was utilized. To reduce the potential for mistake amongst investigators, only one trained investigator examined each patient and collected data. Patients divided according to the treatment procedure into two groups equal in numbers to identify the efficacy of proprioceptive training paradigm on cervical radiculopathy. The faculty of physical therapy's ethical committee at Cairo University, Egypt, gave approval to the study (P.T.REC/012/004187).

- **Sample Size Calculation:**

About 30 participants in each group were required for the present study. The sample size was determined utilizing G*POWER statistical software (G*power version 3.1) with the parameters of 80% power, α level 0.05, as well as effect size of 0.73.

- **Subject's selection:**

Thirty Patients from both genders (8 males and 22 females) with unilateral chronic cervical radiculopathy enrolled in this study. Patients were randomized into two groups of equivalent number (study and control group) utilizing a secure method of opaque closed envelopes that was assigned as group A (study) and group B (control). The study group (A) 15 Patients (3 males and 12 females) received proprioception training paradigm for 30 minutes as well as a specific physiotherapy program for 30 minutes and the control group (B) Patients (5 males and 10 females) received only the same specific physiotherapy program only for 60 minutes. Patients from both genders were diagnosed with chronic cervical radiculopathy according to a careful clinical evaluation by the neurologist and this diagnosis was confirmed radiologically by MRI and X-ray findings of the cervical spine. Patients were recruited from the outpatient clinics of the medical complex in new Cairo, Egypt, as well as the faculty of physical therapy at Cairo University in Egypt.

Included in this study: Thirty Patient diagnosed with unilateral lower cervical spondylotic radiculopathy at level (C6-C7). Both genders participated in the study. Age ranged from 35 to 55 years. Duration of symptoms was more than 6 months. Direction of disc bulge was peripheral. All patients had mobile telecommunication. All patients were not under medication. All patients were medically and psychologically stable.

Excluded in this study: Patients with any cervical myelopathy, cervical myelo-radiculopathy, acute cervical radiculopathy, vertebro-basilar artery insufficiency, diabetic neuropathy, previous cervical or shoulder surgery, cervical trauma, rheumatoid arthritis, any tumors and infection involving the cervical spine and patients without a history of neuromuscular disorders.

Instruments and procedures for Assessment:

Instruments:

Cervical range of motion was measured by using the cervical range of motion device (CROM). The CROM was utilized to measure cervical ROM in all direction. It was simple to use as it required minimal palpation to locate landmarks. It was a cost-effective tool when compared to other motion analysis systems. It had high concurrent validity and test-retest reliability (11).

Body mass index was assessed by using weight and height scale which is used to measure the weight and height, of all patients before starting the assessment. BMI calculated based on the subsequent equation: BMI = mass(kg) / ((height (m))2 (12).

Assessment procedure: After getting detailed information about the study's goals, methods, potential benefits, privacy, as well as data usage, all patients signed a written consent form. All participants were submitted to the following battery of evaluation:

Evaluation of neck pain intensity using visual Analogue Scale (VAS): Visual Analogue Scale (VAS) was used to determine the severity of neck pain. It is a line that is 10 centimeters long and has two ends, one representing no pain and the other representing severe imaginable pain. Subjects were instructed to locate a point on the line which most accurately represented their degree of pain (13). The Visual Analog Scale (VAS) was the gold standard for measuring pain severity because of its reliability, its ease of use, and its wide use (14). In order to participate in the study, participants needed to be having mild to severe neck pain. Evaluation of cervical range of motion using cervical range of motion (ROM) device (CROM) :Patient was seated straight upright in a chair with back support, assumed and maintained this position throughout the test, head of the patient was looking straight forward (neutral head position), hips and knees were at 90 degrees of flexion and feet were fixed the ground, the goniometer was placed on the patient's head and a magnetic collar was attached to their shoulders, Velcro straps were used to secure CROM unit on the head of the patient. The patient was advised not to move their shoulders for the rest of the test. Each movement was stopped when reaching the maximum angle, patient was requested to stop at the end of every movement to enable the therapist to take reading and then return to neutral for a 5–10 s rest, the measurement was taken throughout "half a cycle" of the movement, from neutral to the end of range of motion in a particular plane, therapist recorded ROM in degrees after each movement, and each measurement of the active ROM was followed by instructions in which the therapist demonstrated the movement to be performed by the patients (15). Assessed for cervical ROM of flexion, extension, rotation, and side bending.

Instrumentations and procedure for treatment:

Instruments:

Stabilizer pressure biofeedback unit (version 2006 Encore Medical, L.P.) was utilized to offer Visual feedback to the patient throughout training for spinal stabilization. The airbag biofeedback device could be utilized as a training device to activate deep neck flexor muscles as well as for retraining joint position sense of the cervical spine by trying to replicate neck positions by means of visual feedback was offered by the biofeedback device. The patient holds the specified pressure for ten seconds for a maximum of ten repetitions when using the airbag biofeedback equipment to improve muscular tonic endurance (16).

Interferential therapy was used to provide pain control through the stimulation of nerve fibers in the skin. Interferential therapy was characterized by the interference of two medium frequency currents that were combined to produce low frequency. Interferential therapy was applied transcutaneously via electrode pads by bipolar application (17). Interferential 2p (Pre-modulated) Current was a medium frequency alternating current with symmetrical biphasic sinusoidal pulses. Current came out of one channel (two electrodes). Between the 2 electrodes there was an interferential field with maximal amplitude and 100% modulation depth, comparing with 4-pole interferential current, the 2-pole was easier to apply because only 2 electrodes are used. The pulse amplitude in skin and deeper tissues was the same. This type of current had a relatively strong effect on the skin. Several devices had become available for delivering interferential current, one of these was a device called Unify Guidance E device, Serial number: 72880.

- **Treatment procedures:**

Thirty Patients from both genders (8 males and 22 females) with unilateral chronic cervical radiculopathy enrolled in this study. Patients were randomized into two groups of identical number (A and B), using a secure method of opaque closed envelopes, Group A (study group) consisted of 15 patients (3 males and 12 females) and group B (control group) consisted of 15 patients (5 males and 10 females).

Frequency and duration of treatment was 3 sessions per week, for 4 weeks. Group A (Study group) received proprioceptive training paradigm for 30 minutes and specific physiotherapy program for the next 30 minute and group B (Control group) received only the specific physiotherapy program for 60 minutes.

Paradigm of training included stretching to tight neck muscles, strengthening exercise, neck stabilizer biofeedback and proprioception training to the neck. In order to lengthen structures that had become adaptively shortened as well as hypomobile, manual force was applied during stretching. The goal of static stretching was to lengthen a muscle to the point of pain, hold that position for a set amount of time, and then let the muscle relax back to its normal resting length.

During muscular energy technique (MET), the patient voluntarily contracts his or her muscle(s) in a specific direction versus a counterforce applied by the therapist. Reducing pain, stretching tight muscles and fascia, decreasing muscle spasm, increasing local circulation, strengthening weak musculature, and mobilizing joint limitations are all potential benefits of MET (19).

Muscle energy (ME) procedures were developed to increase range of motion in the joints with the utilization of submaximal, isometric contractions of muscles where the line of pull might produce the intended accessory motion of a joint (20).

The cervical region was focused on by performing retraction, extension, as well as deep flexor strengthening activities (21). Axial extension (cervical retraction) was trained for by the activation and control of the corresponding muscles. In order to accomplish this, the head must be flexed forward, the cervical lordosis must be reduced, and the upper thoracic kyphosis must be flattened (22). Strengthening exercise included deep neck flexors exercises and lower cervical and upper thoracic extensor exercises.

Neck stabilizer biofeedback activates deep segmental muscle in the cervical spine. Proprioception training to the neck muscles included oculomotor exercises. Oculomotor training was done in progressive stages. Before moving the head while maintaining visual fixation on an object, patients first practiced eye movement tracking a target at a comfortable distance (23).

Specific physiotherapy program: (for both groups) included interferential therapy, posture education, manual therapy and manual traction. Patients were taught the necessity of maintaining optimal spinal alignment while seated and standing (24).

There were two categories of manual therapy: thrust manipulation (high velocity and low amplitude) and non-thrust manipulation. Manual therapy techniques used was downglide manipulation technique from supine to increase cervical rotation and side bending range of motion and cross-arm thrust manipulation technique from prone to increase thoracic spine mobility (25).

The muscles along with facet joint capsules may be stretched, and the intervertebral foramina could be widened, with the help of traction approaches. The advantage of manual traction was that the practitioner could modify the amount of force given by adjusting the angle of pull, the position of the head, and the location of the hands (26).

Data analysis and statistical design

Age, weight, height, BMI, sex, as well as the duration of illness were compared using an unpaired t test. The sex distribution of each group was compared using the Chi-squared test. The mean values of the VAS and CROM were compared before and after treatment, as well as among the treatment groups. Multiple comparison post hoc tests with the Bonferroni adjustment were performed. All statistical tests were done at the $p < 0.05$ level of significance. The Windows version of the statistical software for the social sciences (SPSS) version 25 was used for the analyses.

3. RESULTS

Thirty patients of both genders with cervical radiculopathy were randomized into two groups of equal number for this study. Patients' pain levels and cervical ROM were measured utilizing VAS as well as CROM before and after twelve sessions of treatment. The flow diagram of the study's cases is displayed in **Figure 1**.

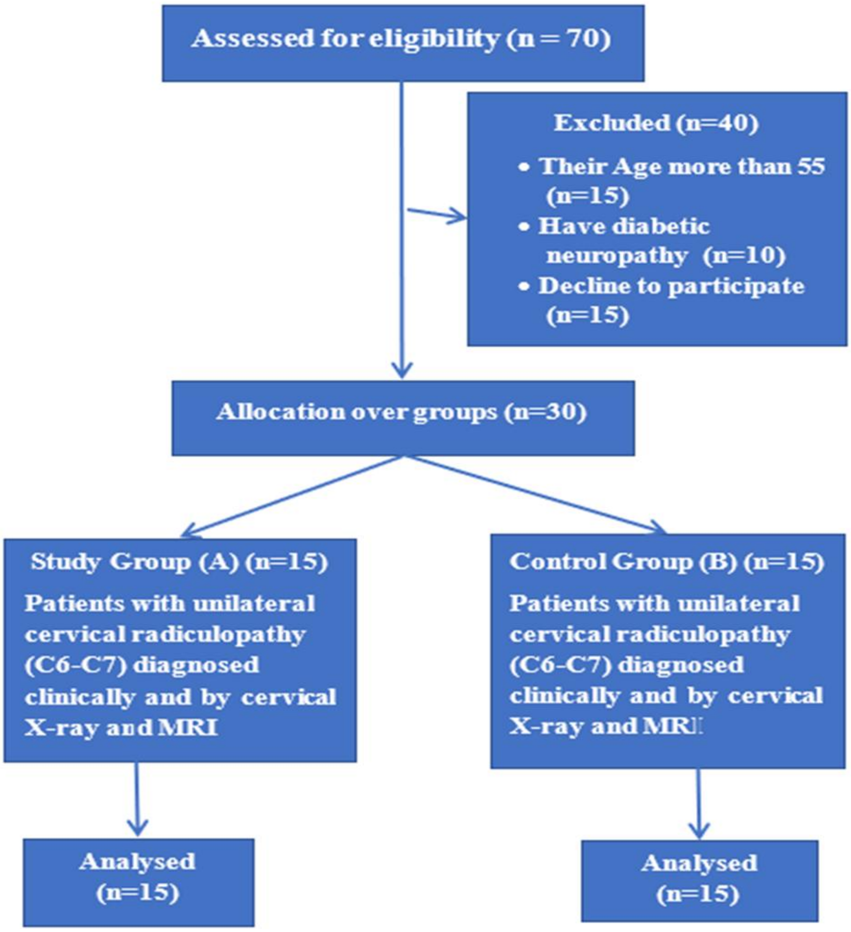

Fig. (1): Consort flow diagram of the study subject characteristics

- Subjects Demographic Data:

The general features of the included patients and healthy subjects are revealed in **table (1).**

Table (1): Comparison of age, weight, height and BMI between group A and B.

	Group A	Group B	MD	t- value	p-value	Sig
	$\overline{X}$ ± SD	$\overline{X}$ ± SD				
Age (years)	50 ± 3.96	49.4 ± 4.01	0.6	0.41	0.68	**NS**
Weight (kg)	80.4 ± 11.36	78.36 ± 10.41	2.04	0.51	0.61	**NS**
Height (cm)	163.4 ± 6.36	164.13 ± 5.72	-0.73	-0.33	0.74	**NS**
BMI (kg/m²)	30.05 ± 3.57	29.01 ± 3.05	1.04	0.85	0.39	**NS**

$\overline{x}$ **: Mean** **SD: Standard deviation** **MD: Mean difference**
t value: Unpaired t value **p value: Probability value** **NS: Non-significant**

I- Effect of proprioceptive training paradigm on Visual analogue scale (VAS):

Concerning to VAS there was a statistically significant decline of VAS in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig.2).**

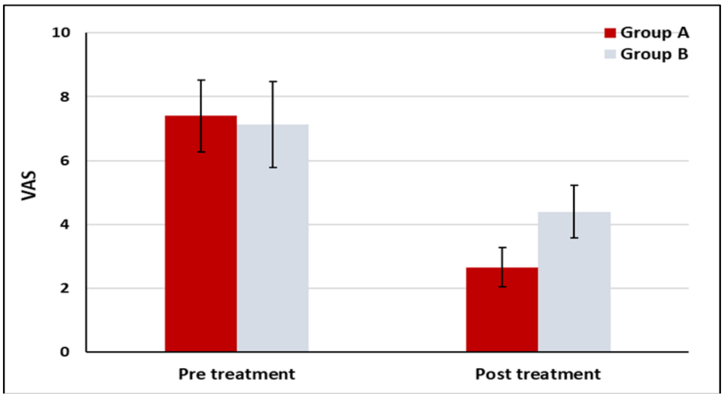

Figure (2). Mean VAS pre and post treatment of group A and B.

II- Effect of proprioceptive training paradigm on cervical flexion ROM:

Concerning to cervical flexion ROM there was a statistically significant improvement in cervical flexion ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 3).**

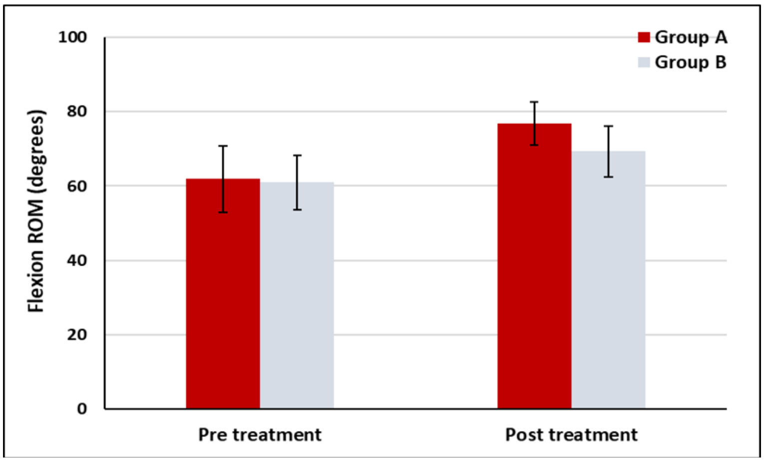

Figure (3). Mean flexion ROM pre and post treatment of group A and B.

III- Effect of proprioceptive training paradigm on cervical extension ROM:

Concerning to cervical extension ROM there was a statistically significant improvement in cervical extension ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 4).**

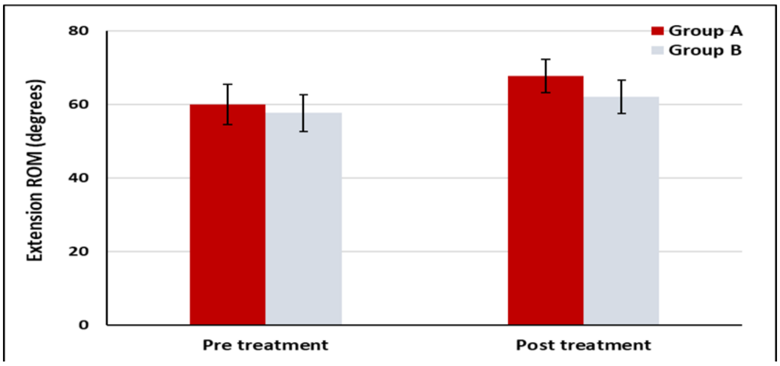

Figure (4). Mean extension ROM pre and post treatment of group A and B.

IV- Effect of proprioceptive training paradigm on cervical right bending ROM:

Concerning to cervical right bending ROM there was a statistically significant improvement in cervical right bending ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 5).**

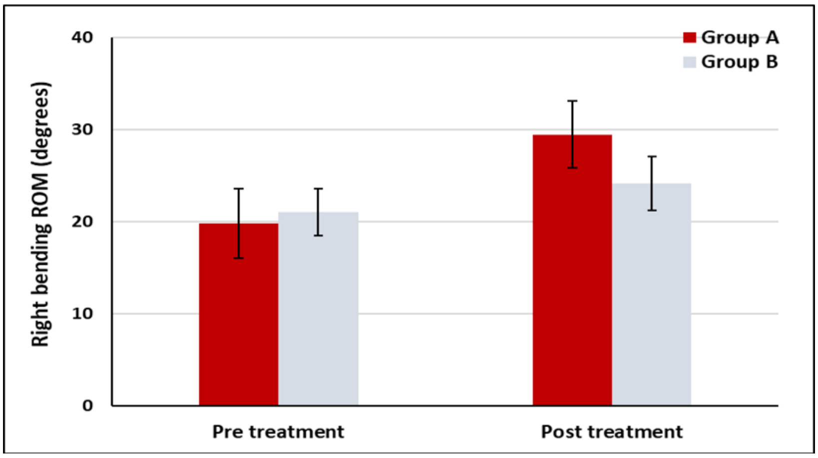

Figure (5). Mean right bending ROM pre and post treatment of group A and B.

V- Effect of proprioceptive training paradigm on cervical left bending ROM:

Concerning to cervical left bending ROM there was a statistically significant improvement in cervical left bending ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 6).**

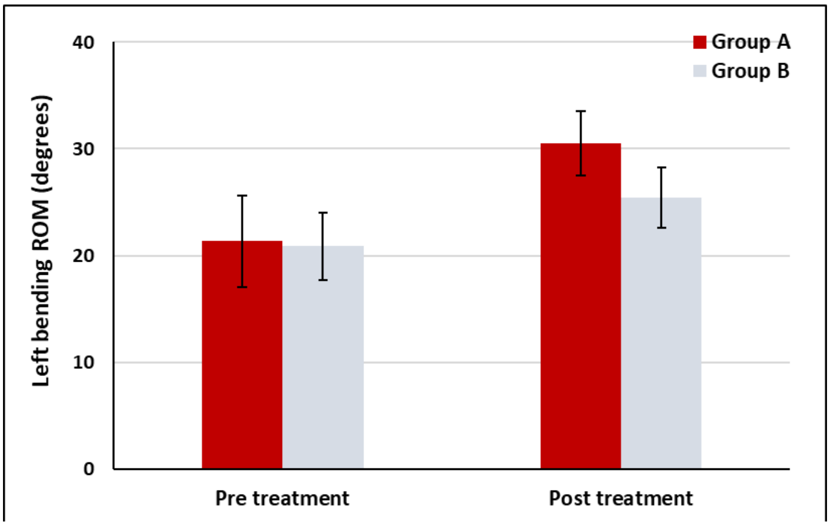

Figure (6). Mean left bending ROM pre and post treatment of group A and B.

VI- Effect of proprioceptive training paradigm on cervical right rotation ROM:

Concerning to cervical right rotation ROM there was a statistically significant improvement in cervical right rotation ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 7).**

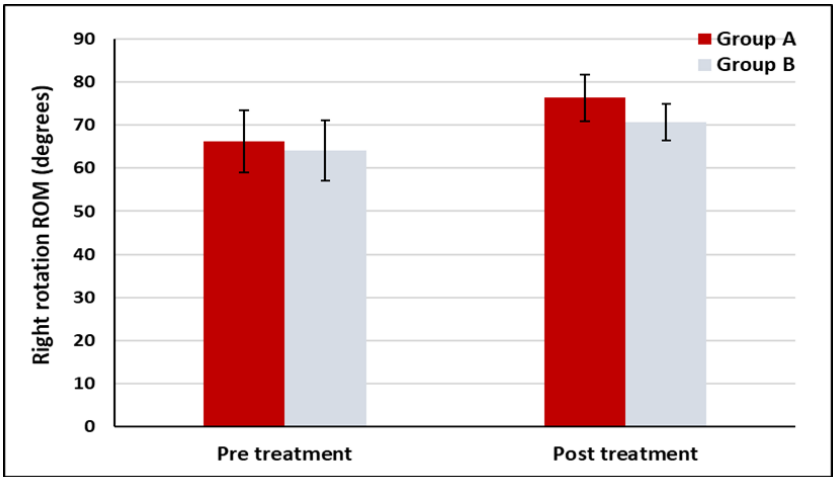

Figure (7). Mean right rotation ROM pre and post treatment of group A and B.

VII- Effect of proprioceptive training paradigm on cervical left rotation ROM:

Concerning to cervical left rotation ROM there was a statistically significant improvement in cervical left rotation ROM in the two groups with favor to study group (G.A) who received proprioceptive training paradigm in comparison with control group (G.B). **(fig. 8).**

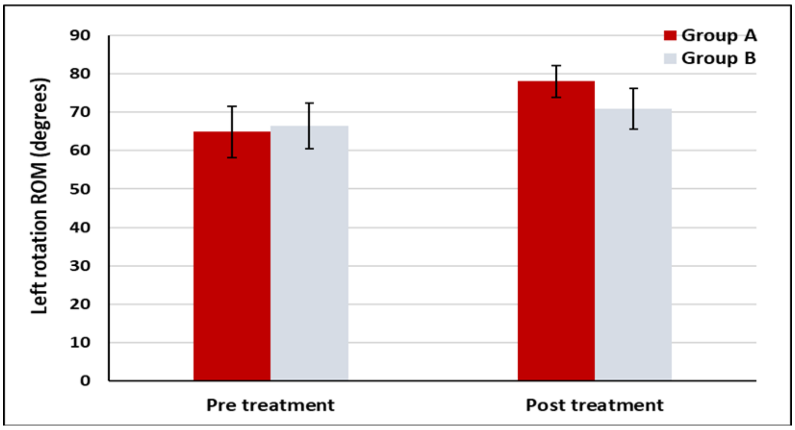

Figure (8). Mean left rotation ROM pre and post treatment of group A and B.

4. DISCUSSION

The aim of this study was to inspect the impact of proprioceptive training paradigm on cervical radiculopathy patients.

Thirty patients with cervical radiculopathy from both genders, their ages ranged from 35 to 55 years were recruited to share in this study. Patients were randomized into two groups of equivalent number, 15 in each group. Group (A) (study group) received proprioceptive training paradigm as well as specific physiotherapy program while group (B) (control group) received only the specific physiotherapy program, Patients were evaluated pre and post 12 treatment sessions to determine cervical range of motion utilizing (CROM) device and pain intensity utilizing VAS.

Concerning to CROM device that was utilized to evaluate cervical ROM and VAS to assess pain intensity there were a statistically significant difference in neck pain level and cervical ROM between both groups. In group B cervical ROM improved and neck pain reduced. While in group A, the improvement turned to become significant in all measured variables.

Our findings of a statistically significant difference in (CROM) device and visual analogue scale (VAS) in cervical radiculopathy patients were supported by the results reported by **Petersen et al.,** who found that eye-head-neck coordination exercises improved both position sense and pain, found that the exercises had a moderate to major treatment impact (28).

Another study supported our findings reported by **Espí-Lópeze et al.,** who compared between cervical mobility exercise and proprioception exercise and stated that there was a statistically significant difference in neck pain and cervical range of motion between both groups before and after the treatment with favor of improvement to group that depend on proprioception exercise. A program focused on cervical mobility exercises was found to reduce pain and disability, although this reduction was not clinically relevant (29).

This study findings of a statistically significant difference in (CROM) device and visual analogue scale (VAS) were supported by the results of **Kramer et al,** who found that when combining resistance training with proprioceptive training, this resulted in much greater muscle hypertrophy and didn't result in a significant decline in proprioceptive capability, compared to using of resistance training alone (30).

Also, our findings of a statistically significant difference in cervical range of motion and pain intensity were supported by the results of Pérez-**Cabezas et al.,** who found an improvement in pain pressure thresholds in the upper trapezius, right levator scapula, as well as left splenius capitis after participating in the Eye-Cervical Re-education Program (31)

Another study conducted by **Stanton et al.,** who concluded that patients with chronic idiopathic neck pain showed moderate impairment in cervical joint position sense (JPS) during head-to-neutral repositioning tests. (32)

Our findings of a statistically significant difference in cervical ROM and pain intensity among the control and study group was in contrary with findings of **Grip, H. et al**. and **Uthaikhup et al.,** They found no statistically significant differences between those with non-traumatic neck pain as well as healthy controls with regards to joint position error (33) & (34).

This study findings of a statistically significant difference in (CROM) device and VAS came in accordance with the findings of **Yong et al.,** who found that repositioning errors were higher among individuals with forward head posture (FHP) compared to those with upright posture (35).

This study results were supported by **Shaghayegh-Fard et al.,** and **Yong et al** who concluded that forward head posture (pain-free) is significantly positively correlated with cervical joint position error. (36) & (37).

Moreover, our findings of a statistically significant difference in (CROM) device and VAS were supported by the findings of **Liang et al.,** who revealed a reduction in VAS in cervical radiculopathy (C.R) patients and this indicated that exercise only or exercise combined with other treatment may be useful in patients with CR. (38)

Additionally, **Kim et al.** showed that deep cervical flexor (DCF) activation exercise helped patients with neck pain in pain relief, function recovery, and a correction of their rounded forward head position. As a result, it may be suggested for use in the treatment of chronic neck pain. (39)

According to **Arimi et al.** results who stated that specified low-load craniocervical flexion exercises were highly successful in enhancing deep cervical flexor muscles for individuals with chronic neck pain when compared to other forms of exercises (40).

Another study came in consistent with this study was reported by **Kong et al.** which concluded that modified cervical exercises produced an improvement in forward head posture (FHP) that was caused by utilizing a smartphone. (41).

Another study supported the results of this study was reported by **Price et al.,** they found that exercise training (ET) focused on motor control and segmental activities had the greatest short-term benefit on reducing pain and disability; however, long-term effects have not been studied (42)

Our findings of a statistically significant difference in cervical range of motion and pain intensity were supported by the results of **Suvarnnato et al.,** who concluded that 6 weeks of training in both exercise groups (semispinalis cervices training and deep cervical flexor training) could improve pain intensity, CV angle, as well as neck-muscle strength in chronic mechanical neck pain. (43)

This study findings of a statistically significant difference in (CROM) device and visual analogue scale (VAS) were supported by the results of **Blomgren et al.,** who concluded that deep cervical flexor training could successfully address impaired neuromuscular coordination and when trying to address all the different physiological issues that come from having a painful neck, a multimodal training program was suggested (44).

Also, our findings of a statistically significant difference in (CROM) device to assess cervical range of motion and VAS to assess pain intensity were supported by the findings of **Park et al.,** who concluded that deep neck flexor exercise can effectively reduce neck pain. Thus, deep neck flexor exercise was highly recommended as an effective exercise method for individuals suffering from neck pain. (45).

This study outcomes of a statistically significant difference in cervical range of motion and pain intensity were supported by **Tsiringakis et al.,** who found that pressure biofeedback exercises of deep neck flexors were more beneficial than strength-endurance training of cervical muscles in reducing disability as well as pain in patients with neck pain (46).

Our findings of a statistically significant difference in (CROM) device and visual analogue scale (VAS) were supported by the results of **Sadeghi et al.,** who suggested that isometric workouts could help the reduction of pain and disability associated with cervical spondylosis (47).

The results of this study were confirmed by those of **Sitharthan et al.,** who found that patients with chronic neck pain benefited from stabilizer pressure biofeedback (SPB) because it provided accurate input regarding the isolation of deep neck flexor contraction. (48).

Our results were supported by the results of another study by **Nezamuddin et al.,** who found that people with low muscle performance benefited more from a 6-week pressure-biofeedback intervention than from the exercise program only (49).

The results of this study were supported by the findings of **Kang et al.,** who found that training deep cervical flexors with a pressure biofeedback device helped those with forward head posture (FHP) preserve the mobility of their necks and the endurance of muscles (50).

The results obtained from this study came in consistent with findings of **Akkan et al.,** who found that stability exercise training reduced pain, increased quality of life, and improved posture in individuals suffering from cervical radiculopathy (51).

Another study conducted by **Zhou et al.,** who concluded that pressure biofeedback combined with deep neck flexor exercises can effectively alleviate the symptoms of chronic neck pain, feedback real-time exercise results for patients, and increase the sustainability of functional exercises, which is a simple, convenient, and low-cost treatment for neck pain and can be a part of the community re-education program for prophylaxis and treatment. (52).

The results obtained by **Alfawaz et al.,** came in consistent with our study results who found that active ranges of motion in the cervical region (extension, right rotation, as well as side bending) were improved by stretching in combination with conventional procedures but not pain nor disabilities (53).

Static as well as diagonal stretching exercises were found to be equally efficient by **Park et al.** to increase ROM (54).

Another study supported our findings was reported by **Nugraha et al.,** who reported an improvement in ROM, functional performance, as well as muscle thickness after using (muscle energy techniques) MET for cervical treatment, as measured by the International Classification of Functioning, Disability, and Health (ICF) criteria of pain rating, pain threshold, ROM, as well as functional performance (55).

Another study conducted by **Diab, A. A., & Moustafa, I. M** concluded that in cases of lower cervical spondylotic radiculopathy, FHP correction utilizing a posture corrective exercise program as well as ultrasound and infrared radiation reduced pain and craniovertebral angle and improved the peak-to-peak amplitude of dermatomal somatosensory evoked potentials for C6 and C7. (56).

5. CONCLUSION

According to the findings of this study, it can be concluded that proprioceptive training paradigm has a statistically significant effect for alleviating pain and improving cervical range of motion in cervical radiculopathy patients.

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