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Effectiveness of eye-cervical re-education versus motor imagery therapy on chronic neck pain: A randomized controlled trial

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ABSTRACT

The aim of this study was to investigate the effect of adding eye cervical re-education exercises (ECRE) versus motor imagery therapy (MIT) to conventional physical therapy (CPT) on pain, functional disability, and cervical range of motion (ROM) in subjects with chronic neck pain (CNP). The study employed a randomized controlled trial design with 60 patients with CNP. Participants were selected from the outpatient clinics of the Faculty of Physical Therapy at Cairo University and were randomly assigned to three groups: conventional physical therapy only (CPT) (Group I, N = 20), eye-cervical re-education exercises plus CPT (Group II, N = 20), and motor imagery therapy plus CPT (Group III, N = 20). All participants received 3 sessions per week for 4 weeks. Visual Analogue Scale (VAS), Neck Range of Motion (ROM) and Neck Disability Index (NDI) were measured at baseline and after 4 weeks of intervention. In terms of pain intensity, neck disability index, neck flexion and extension, right and left lateral flexion, and right and left rotation ROM outcome measures, the results revealed statistically significant differences between groups ($p < 0.05$). Group II showed statistically significant improvement compared to both Group I and Group III in all measured outcomes ($p < 0.05$). Additionally, Group III showed statistically significant improvement compared to Group I in all measured outcomes ($p < 0.05$). Adding eye-cervical re-education exercises or motor imagery therapy to conventional physical therapy resulted in notable improvements. Eye-cervical re-education exercises, in particular, showed greater benefits in reducing pain, enhancing cervical ROM, and decreasing disability compared to conventional physical therapy alone in patients with chronic neck pain.

KEYWORDS

Eye Cervical Re-Education; Motor Imagery; Chronic Neck Pain; Disability; Range of Motion

1. INTRODUCTION

Chronic neck pain (CNP) is a prevalent problem among employed people in modern, industrialized nations (Kääriä et al., 2012). Acute neck pain occurs suddenly and typically resolves within a few days to weeks. Neck pain is usually caused by issues with the discs, joints, muscles, or ligaments. Chronic neck pain, on the other hand, lasts more than three months and can intensify during certain activities or persist all the time (Fritz & Brennan, 2007).

The number of cervical mechanoreceptors and their reflex connections to the ocular, vestibular, and central nervous systems provide evidence that the cervical spine plays a significant role in delivering proprioceptive input (Treleaven, 2008). Chronic neck pain impairs cervical proprioception, causing sensory disruptions and decreased postural control (Lukasiewicz et al., 2000). When the motor output of the cervical muscles is compromised, the deep postural muscles are less active, directional specificity is lowered, the initiation of muscle responses is delayed, co-contraction of the neck muscles is increased, and cervical muscle strength is reduced (Lindstrøm et al., 2011).

Eye-cervical re-education exercises (ECRE) refer to a therapeutic technique for adjusting posture at the cephalic level in patients with cervical pain. The therapeutic effect of ECRE is enhancing eye-head proprioception thereby reducing symptoms that concern patients (Perez-Cabezas et al., 2015). Eye-cervical re-education exercises play an important role in improving cervical afferent input performance to the central nervous system, involving specific contractions of cranio-cervical muscles, which have a high density of muscle spindles (Pérez-Cabezas et al., 2020).

Motor imagery therapy is utilized for convoluted pain and neuro-motor defect. It involves utilizing specialized imagery (imagined or real) to teach the brain to become less sensitive to pain (Röijezon et al., 2015). Motor imagery has an effect in improving sensorimotor function. It also improves several motor aspects, such as motor learning, neuro-motor control, and acquisition of motor skills (Kilintari et al., 2016).

The rehabilitation process for CNP patients emphasizes the accuracy of proprioceptive function (Kristjansson & Treleaven, 2009). Various researchers have revealed that proprioception impairment may lead to pain and disability through poor motor control (Ghamkhar et al., 2018). Rehabilitation of these proprioceptive deficiencies is key to treating patients with CNP. Proprioception training utilizes the unconscious element of proprioceptive inputs for the automatic control of cervical muscle tone and posture, offering an additional advantage over traditional exercise programs (Treleaven, 2008).

To the best of the researcher's knowledge, there is a lack of research investigating the effect of ECRE or MIT programs on patients with CNP. The aim of this study is to investigate the effect of adding eye cervical re-education exercises (ECRE) versus motor imagery therapy (MIT) to conventional physical therapy (CPT) on pain, functional disability, and cervical range of motion (ROM) in subjects with chronic neck pain (CNP).

2. METHODS

2.1. Study design and setting

The current study employed a randomized controlled trial design. Patients were selected from the outpatient clinics of the Faculty of Physical Therapy at Cairo University. The clinical practice of therapeutic programs and the physical evaluation of patients were conducted at the Faculty of Physical Therapy, Cairo University, between October 2020 and January 2023. The study was approved by the Ethical Committee for Human Research at the Faculty of Physical Therapy with reference number P.T. REC/012/003003. A formal consent form was provided to each patient before participation, and all patients accepted the invitation to participate. The study was registered at the Pan African Clinical Trials Registry with registration number PACTR202111856730525.

2.2. Participants

Sixty patients with CNP participated in the study and were randomly assigned to three equal groups. The intervention groups were as follows: conventional physical therapy only (Group I, N = 20), eye-cervical re-education exercises plus CPT (Group II, N = 20), and motor imagery therapy plus CPT (Group III, N = 20). Participants were included if they were between 20 and 45 years old and had persistent cervical pain for more than three months, as diagnosed by a physician. Patients were excluded if they had dizziness syndrome, post-traumatic conditions such as whiplash, cervical pain caused by neural conditions, cervical neoplasm, were pregnant, had speech and understanding problems, or had a history of neck surgery.

2.3. Sample size and randomization

To find out whether there were any clinically significant changes between the groups of 20 mm on pain intensity and 10.5 points on neck disability index, G*power (version 3.1.9.6, Dusseldorf, Germany) was used to estimate the sample size using a 0.45 effect size, 20% beta error, and a twosided 0.05 alpha error. The impact size was determined by using a pilot research with 5 volunteers in each group. In order to take into account the dropout, the size was raised by 15% to be 60 participants from the original predicted sample size of 51 patients. Sixty individuals were randomly divided into three equal groups. The author who created the randomization was not involved in the data collection process. To remove the potential for bias and reduce the variance between the groups, a computer-generated block randomization with block sizes between 6 and 9 was used during the study. Participants were distributed invisibly using sealed, numbered, sequential envelopes. The researcher began by opening the envelopes and then continued with the therapy in accordance with group classifications.

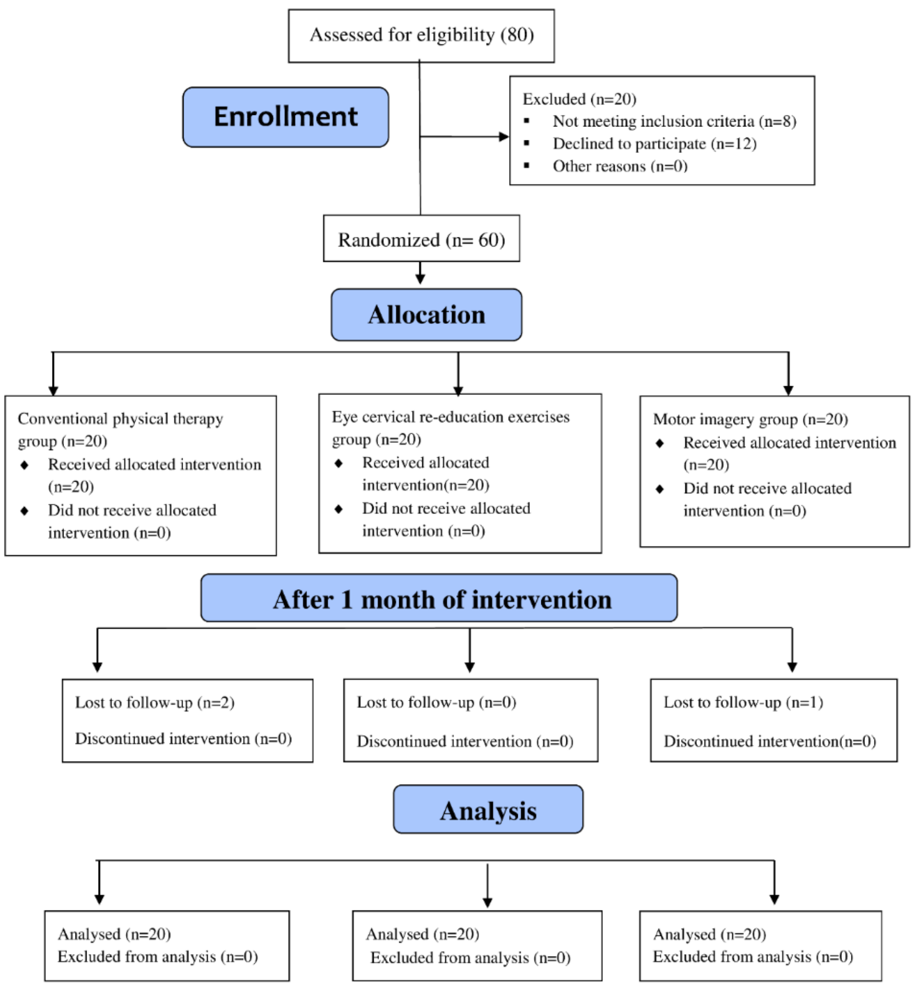

Figure 1. Participants' flow chart

2.4. Outcome measures

The same examiner, who was blinded to the group allocation, assessed all outcome measures immediately before treatment began and immediately after the 4-week intervention.

2.4.1. Visual Analogue Scale (VAS)

The Visual Analogue Scale (VAS) is considered a reliable and valid method for estimating pain intensity levels (Ferreira-Valente et al., 2011). It was used to assess pain intensity in this study. The VAS typically consists of a horizontal line 100 mm in length, anchored by "no pain" (score of 0) at one end and "pain as severe as it could be" or "worst feasible pain" at the other end. Patients are asked to mark the point on the horizontal line that best represents their perception of their current pain state (Flynn et al., 2004).

2.4.2. Neck Functional Disability Scale

The Neck Functional Disability Scale is a reliable, valid, and sensitive method for evaluating changes in pain and disability in patients with neck pain. It consists of a 10-question survey designed to assess the level of disability perceived by patients in their daily lives. Each question has six answer options, ranging from 0 (no disability) to 5 (completely disabled) (Vernon, 2008).

2.4.3. Cervical Range of Motion Device (CROM)

The Cervical Range of Motion (CROM) device was utilized to assess cervical range of motion (ROM). The CROM instrument is a reliable, valid, and objective tool for evaluating all planes of cervical spine motion (Tousignant et al., 2006). It is composed of three inclinometers; the first inclinometer was positioned in the sagittal plane. The second inclinometer was positioned in the frontal plane that were attached to the frame and indicate the position of the neck in related to the line of gravity. The third inclinometer was placed in the horizontal plane and represents the position of cervical rotation in related to a reference position (Audette et al., 2010).

2.5. Intervention

All three groups of patients were given a traditional physical therapy program that included isometric strength exercises, therapeutic massage, and heat application.

- **The control group (I)** received conventional physical therapy program that includes therapeutic massage (the therapist stood beside the patient while he was in relaxed prone lying position), heat application, and isometric exercises. The therapist executed a compression massage for ten minutes, friction massage for two minutes and ten minutes of kneading massage. Heat packs were placed on posterior cervical area for 10 minutes while the patient was relaxed prone lying position. Isometric exercises were applied with sustain 5 sec in all cervical motion (flexion, extension, side bending and rotation) with ten repetitions for each direction while the patient sits in erect position and the therapist stood back of the patient (Sherman et al., 2009; Garra et al., 2010; Khan et al., 2014).

- **The eye cervical re-education group (II)** received eye cervical re-education exercises program. This program composed of ten exercises that re-training of proprioceptive input in the cervical spine through the three following phases: a) Ocular mobility without cervical movement phase, this phase has a two exercise like as ocular muscles activation exercise and cervical passive movement with eye fixed in vertical direction exercises. b) Cervical mobility exercises phase, this phase has five exercises as analytical exercises on cervical mobility exercises, global exercise of cervical movement, cervical mobility work with the trunk exercise, head reposition exercise (first degree) exercises and head reposition exercise (second degree). c) eye-cervical co-ordination exercise phase, it has three exercises as a free coordination exercise, manual resistance co-ordination exercise and finally oculo-cervical co-ordination and multidirectional manual stimuli work exercise (Pérez-Cabezas et al., 2020; Asiri et al., 2021; Humphreys & Irgens, 2002; Balbaa & Ayad, 2006). All details about the eye-cervical re-education program are presented in Supplementary 1 (Kääriä et al., 2012).
- **Motor Imagery Group (III)** received motor imagery therapy program which have 4 phases. A kinesthetic Imagery phase that was applied in the first week of the intervention. A motor imagery therapy phase that was applied on second week of the intervention. An action observation with motor imagery phase was applied on the third week of intervention. A cervical motor control exercise in front of mirror phase was applied on fourth week of intervention. A cervical motor control exercises included four exercises as Cranio-cervical flexor exercise, Co-contraction of neck flexors and extensors, Cranio-cervical extensor exercise and scapular re-education exercises. A scapular re-education exercises included Wall Slides Exercise, Scapular Retraction, Y and W Exercise (For Rhomboids and Lower traps) and Levator Scapulae Muscle Stretch (ÖZCAN et al., 2019; Park et al., 2017; Javdaneh et al., 2021). All details about the motor imagery therapy program are presented in Supplementary 2 (Fritz & Brennan, 2007).

Supplementary 1. Eye Cervical Re-education Program Description

Exercise's name	Description
1. Activation of Ocular Muscles	The patient was seated in an erect position. They performed maximum amplitude ocular movements actively, including upward, downward, upward to the right, upward to the left, toward the right, toward the left, downward to the right, and downward to the left, without any cervical movement. The exercise was first done with the eyes open and then repeated with the eyes closed, with each movement repeated 3 times.
2. Passive Movement of the Cervical Spine with Eyes Fixed	The patient was seated on a chair in an erect position. The therapist stood at the height of the patient's head and performed passive movements of the cervical spine, including rotation, side bending, and flexion-extension. Then, the patient tried to keep their eyes fixed on a point in the vertical direction.
3. Analytical exercises on Cervical Mobility	The patient was seated in front of the therapist. The patient was instructed to keep their gaze fixed on an object while moving the cervical spine in all directions (flexion, extension, side bending, and rotation). Each direction was held for 10 seconds before returning to the starting position. This was repeated 3 times.
4. Global Exercise of Cervical Movement	The patient was seated in an erect position on a chair in the middle of the room. The therapist placed graphic pictures on the wall in front of and behind the patient, positioned in different directions (upward, up to the right, up to the left, right, and left). The patient was instructed to follow each picture with their eyes.
5.Cervical Mobility Work With the Trunk	The patient stood in front of a graphic-painted paper on the wall. The therapist stood behind the patient. The patient was asked to fix their gaze on the graphic-painted paper while rotating their trunk to the right and left. During this, the therapist destabilized the trunk in all directions.
6. Head Reposition Exercise (first degree).	The patient was seated in an erect position in front of a mirror. The therapist stood behind the patient and supported their shoulders with both hands. The patient was asked to memorize the neutral position, then close their eyes and perform each cervical movement (flexion-extension, rotations, and lateral flexions) without opening their eyes. The patient should try to return to the starting position. This was repeated 3 times for each movement.
7. Head Reposition Exercise (second degree)	The patient was seated in an erect position in front of a mirror. The therapist stood behind the patient and destabilized their trunk. Similar to Exercise 6, the therapist destabilized the patient's trunk in different directions while the patient tried to maintain an erect position and reposition their head from each movement (flexion, extension, rotation, side bending) back to the starting position without opening their eyes. This was repeated 3 times for each movement.
8.Free Co-ordination Exercise	The patient was seated in an erect position. The therapist sat in front of the patient with an object in hand. The patient was asked to follow the object, which the therapist directed to achieve the maximum amplitude in each movement (upward, downward, up to the right, up to the left, down to the right, down to the left, right, and left directions). This was repeated twice for each movement.
9.Manual Resistance Coordination Exercise	The patient was seated in an erect position. The therapist, standing, provided manual resistance. The patient was asked to perform cervical movements in all directions and return to the neutral position. The therapist applied manual resistance during each movement.

Exercise's name	Description
10.Oculo-Cervical Coordination and Multidirectional Stimuli	The patient sits in an erect position while the therapist stands behind them. The therapist performs head destabilization while the patient turns their head to the neutral position. This is repeated twice for each direction.

Supplementary 2. Motor Imagery Therapy program description

Exercise's name	Exercise's description
1.Kinesthetic Imagery Stage (1st week)	The patient was seated in an erect position, and the therapist was seated in front of the patient. The therapist collected pictures from the internet depicting cervical movements of right and left discrimination in different directions. The patient was asked to concentrate on the training, look at each picture, and try to detect the direction of movement (right or left rotation or side bending) shown in the pictures without performing any cervical motion. The duration of the exercise was 15 minutes.
2. A Motor Imagery Therapy Stage (2nd week)	The patient was seated in an erect position and asked to close their eyes and concentrate on the training. The therapist was seated in front of the patient. The therapist explained the cervical motions to the patient, then guided the patient to think of cervical spine motions (flexion, extension, side bending, and rotation) without any body movement, trying to form a visual mental image or picture of each cervical motion. The duration of the exercise was 15-20 minutes.
3. Action Observation with Motor Imagery. 3rd week	The patient was seated in an erect position and asked to close their eyes and concentrate on the training. The therapist was seated in front of the patient. The therapist performed cervical motor control exercises in front of the patient, including cranio-cervical flexor exercise, co-contraction of neck flexors and extensors, cranio-cervical extensor exercise, and scapular re-education. The patient observed each exercise, then tried to imagine themselves performing the exercise without any body movement. The duration was 30 minutes.
4. Cervical Motor Control Exercise in front of Mirror. 4th week	The positions of the patient and therapist were changed according to each cervical motor control exercise. The patient performed cervical motor control exercises in front of mirrors, which included cranio-cervical flexor exercises, co-contraction of neck flexors and extensors, cranio-cervical extensor exercises, and scapular re-education.

2.6. Statistical analysis

SPSS for Windows version 25 (SPSS, Inc., Chicago, IL) was used to statistically analyze and compare the measured variables, with an alpha level set at 0.05. An intention-to-treat analysis with multiple imputation methods was used to address dropout. Data were checked for the presence of extreme scores, homogeneity of variance, and the assumption of normality. The measured variables were found to be normally distributed ($p > 0.05$) according to the Shapiro-Wilk test. Except for gender (reported as counts/percentages), data are expressed as mean and standard deviation. The combined impact of all outcomes was compared between groups using a two-way mixed-design MANOVA. When MANOVA results were statistically significant, univariate ANOVAs with the Bonferroni correction were performed for each outcome to guard against Type I error.

3. RESULTS

There are no statistically significant differences between the demographic and clinical characteristics of participants across the three groups at baseline, as indicated by p-values greater than 0.05 (Table 1).

Table 1. The baseline demographic and clinical characteristics of participants in three groups

Characteristics	Group I (n=20)	Group II (n=20)	Group III (n=20)	F Value	p value
Age (years)	33.25±6.63	33.95±7.8	33.35±7.21	0.02	0.98
Weight(kg)	75.55±11.35	71.65±12.13	73.35±12.81	0.52	0.6
Height(cm)	169.1±9.21	166.7±8.91	167.6±10.82	0.31	0.73
BMI (kg/m2)	26.41±3.37	25.76±3.75	25.99±2.84	0.19	0.82
Sex (M/F)	8/12	8/12	9/11	X^2 =0.14	0.93
VAS (mm)	71.8±8.02	79.9±7.41	74.0±4.54	1.82	0.17
NDI	37.7±3.74	35.3±4.14	37.25±4.17	1.82	0.17
Flex (deg.)	33.5±4.94	32.3±3.51	34.8±2.78	2.11	0.13
Ext. (deg.)	32.0±5.35	34.5±6.8	31.9±6.34	1.13	0.33
RLF (deg.)	29.5±5.23	26.8±4.87	26.0±4.94	2.67	0.08
LLF (deg.)	30.8±5.96	28.35±4.6	27.5±5.02	2.15	0.13
RR (deg.)	38.3±5.04	38.0±5.84	36.0±6.46	0.93	0.4
LR (deg.)	38.4±5.49	39.3±5.32	37.1±6.27	0.75	0.48

*BMI, Body mass Index; VAS, Visual Analogue Scale; NDI (neck disability index ; Flex, Flexion, deg., degrees; Ext, Extension; RR, Right Rotation; LR, Left Rotation; RLF, Right Lateral Flexion; LLF, Left Lateral Flexion; F, fisher test; p, probability value; M, male; F, Female; m, meter, Kg; * Data are mean± SD, P-Value < 0.05 indicate statistical significance*

The difference between participants in the three groups in the amount of change in their scores on the outcome measures was evaluated by using a mixed design multivariate analysis. For the main effects of groups, Wilk's A = 00.4, F(16,100) = 3.67, P< 0.001, η2 = 0.37, for time, Wilk's A = 0.01, F(8,50) = 745.8, p < 0.001, η2 = 0.99, and for the interaction between groups and time, Wilk's A= 0. 04, F (16,100) = 24.13, p < 0.001, η2 = 0.79.

After four weeks of intervention, follow-up univariate ANOVAs show statistically significant changes for all outcome variables: VAS *F(2,57) = 59.35, p = 0.001, η2 = 0.68*, neck disability index *F(2,57) = 53.45, p = 0.001, η2 = 0.65*, flexion *F(2,57) = 17.0, p = 0.001, η2 = 0.37*, extension *F(2,57) = 37.6, p = 0.001, η2 = 0.57*, RLF *F(2,57) = 32.94, p = 0.001, η2 = 0.54*, LLF *F(2,57) = 23.05, p = 0.001, η2 = 0.45*, RR *F(2,57) = 31.46, p = 0.001, η2 = 0.53*, and LR *F(2,57) = 39.39, p = 0.001, η2 = 0.58.*

Table 2. Clinical characteristics of subjects after 4 weeks of intervention

Characteristics	Group I (n=20)	Group II(n=20)	Group III(n=20)	F-Value	P Value
VAS (mm)	53.25±9.3	27.65±5.91	44.9±7.14	59.35	0.0001
NDI	22.3±3.89	9.9±3.13	18.05±4.43	53.45	0.0001
Flex(deg.)	39.5±5.5	47.6±3.93	43.4±3.5	17.00	0.0001
Ext.(deg.)	37.7±5.03	53.7±5.52	44.7±6.88	37.6	0.0001
RLF(deg.)	33.5±4.81	43.3±4.8	37.5±2.59	32.94	0.0001
LLF(deg.)	35.0±4.66	43.5±2.89	39.3±4.12	23.05	0.0001
RR(deg.)	43.5±4.63	57.3±6.2336	48.8±5.67	31.46	0.0001
LR(deg.)	44.1±4.92	59.1±4.7	50.45±6.33	39.39	0.0001

*VAS, Visual Analogue Scale; NDI, Neck Disability Index; Flex, Flexion, deg., degrees; Ext, Extension; RLF, Right Lateral Flexion; LLF, Left Lateral Flexion; RR, Right Rotation; LR, Left Rotation; CI, Confidence interval; p, probability value. * Data are mean± SD, P-Value < 0.05 indicate statistical significance*

In terms of pain intensity, neck disability index, neck flexion and extension, right and left lateral flexion, and right and left rotation ROM outcome measures, the results revealed statistically significant differences between groups (p<0.05). Group II showed statistically significant improvement compared to both Group I and Group III in all measured outcomes (p < 0.05). Additionally, Group III showed statistically significant improvement compared to Group I in all measured outcomes (p < 0.05) (Table 3).

Table 3. Between-groups differences after 4 weeks of intervention

Outcome	Group I Versus Group II		Group I Versus Group III		Group II Versus Group III		Partial Eta Square
	MD (95% CI)	**P-Value**	**MD (95% CI)**	**P-Value**	**MD (96% CI)**	**P-Value**	
VAS (mm)	25.6 (19.67, 31.51)	<0.0001	8.35 (2.44 -14.26)	0.003	-17.25 (-23.16, -11.34)	<0.0001	0.68
NDI	12.4 (9.39, 15.41)	<0.0001	4.25 (1.24, 7.26)	0.003	-8.15 (-11.16, -5.14)	<0.0001	0.65
Flex(deg.)	-8.15 (-11.53, -4.67)	<0.0001	-3.9 (-7.33, -0.47)	0.02	4.2 (0.77, 7.63)	0.01	0.37
Ex(deg.)	-16.0 (-20.56, -11.44)	<0.0001	-7.0 (-11.56, -2.44)	0.001	9.0 (4.44, 13.56)	<0.0001	0.57
RLF(deg.)	-9.8 (-12.8, -6.81)	<0.0001	-4.0 (-7.0, -1.01)	0.005	5.8 (2.81, 8.8)	<0.0001	0.54
LLF(deg.)	-8.5 (-11.59, -5.41)	<0.0001	-4.3 (-7.34, -1.21)	0.003	4.2 (1.11, 7.29)	0.004	0.45
RR(deg.)	-13.8 (-18.13, -9.47)	<0.0001	-5.3 (-9.63, -0.97)	0.01	8.5 (4.17, 12.83)	<0.0001	0.53
LR(deg.)	-15.0 (-19.19, -10.82)	<0.0001	-6.35 (-10.54, -2.17)	0.001	8.65 (4.47, 12.84)	<0.0001	0.58

*VAS, Visual Analogue Scale; NDI, Neck Disability Index; Flex, Flexion, deg., degrees; Ext, Extension; RLF, Right Lateral Flexion; LLF, Left Lateral Flexion; RR, Right Rotation; LR, Left Rotation; CI, Confidence interval; p, probability value. * Data are mean± SD, P-Value < 0.05 indicate statistical significance. *Data are mean± SD, P-Value < 0.05 indicate statistical significance.*

After 4 weeks of intervention, all groups showed statistically significant differences on all outcome measure (p<0.05) when comparing within-group results (Table 4).

Table 4. Within-group differences from baseline to after 4 weeks of intervention

Outcomes	**Group I(n=20)** Change from baseline to 4weeks		**Group II(n=20)** Change from baseline to 4weeks		**Group III(n=20)** Change from baseline to 4weeks	
	MD (99% CI)	**P Value**	**MD (99% CI)**	**P Value**	**MD (99% CI)**	**P Value**
VAS (mm)	18.55 (16.16, 20.94)	<0.0001	42.25 (39.86, 44.64)	<0.0001	29.1 (26.71, 31.49)	<0.0001
NDI	15.4 (14.04, 16.75)	<0.0001	25.4 (24.04, 26.76)	<0.0001	19.2 (17.84, 20.56)	<0.0001
Flex(deg.)	-6.0(-7.48, -4.52)	<0.0001	-15.3(-15.78, -13.82)	<0.0001	-8.6(-10.08, -7.12)	<0.0001
Ex(deg.)	-5.7(-7.05, -4.35)	<0.0001	-19.2(-20.55, -17.85)	<0.0001	-12.8(-14.15, -11.45)	<0.0001
RLF(deg.)	-4.0(-5.24, -2.76)	<0.0001	-16.5(-17.74, -15.26)	<0.0001	-11.5(-12.74, -10.26)	<0.0001
LLF(deg.)	-4.2(-5.75, -2.65)	<0.0001	-15.15(-16.7, -13.6)	<0.0001	-11.8(-13.35, -10.25)	<0.0001
RR(deg.)	-5.2(-6.73, -3.67)	<0.0001	-19.3(-20.83, -17.77)	<0.0001	-12.8(-14.33, -11.27)	<0.0001
LR(deg.)	-5.7(-7.03, -4.37)	<0.0001	-19.8(-21.13, -18.47)	<0.0001	-13.35(-14.68, -13.02)	<0.0001

VAS, Visual Analogue Scale; NDI, Neck Disability Index; Flex, Flexion, deg., degrees; Ext, Extension; RLF, Right Lateral Flexion; LLF, Left Lateral Flexion; RR, Right Rotation; LR, Left Rotation; CI, Confidence interval; p, probability value. * Data are mean± SD, P-Value < 0.05 indicate statistical significance. * Data are mean± SD, P-Value < 0.05 indicate statistical significance.

4. DISCUSSION

The major findings of this study revealed statistically significant differences between the three groups, favoring the eye-cervical re-education exercise group. Significant improvements were observed in the Neck Disability Index, pain intensity, cervical extension, flexion, left and right lateral flexion, and left and right rotation range of motion (ROM) outcome measures ($p < 0.05$). Both the eye-cervical re-education exercises and motor imagery groups showed better improvements compared to the control group ($p < 0.05$).

The results of the current study demonstrated the superiority of the eye-cervical re-education (ECRE) program over motor imagery therapy (MIT) and traditional physical therapy in terms of pain intensity, disability, and cervical range of motion (ROM). The proposed mechanism by which the ECRE program reduces pain sensation in the cranio-cervical muscles involves enhancing muscle spindle function and improving eye-head coordination, which in turn enhances proprioception (Izquierdo et al., 2016). The improvement in cervical proprioception can be attributed to the ECRE program's facilitation of proprioceptive inputs, which aids in the autonomic control of cervical muscle posture and tone (Jull et al., 2009).

The ECRE approach contributes to decreasing cervical disability through the enhancement of the contractile capability of the cervical deep flexor muscles (Proske & Gandevia, 2012). The highest density of motor receptors is seen in these muscles. Additionally, it is known that these muscles play a special role in reflex and central connections to the ocular, vestibular, and postural control systems (Ghamkhar et al., 2018). Therefore, these muscles enable control of cephalic posture and segmental movements of the cervical spine, resulting in improved cervical function (Boyd-Clark et al., 2002). Furthermore, ECRE enhances the quality of cervical afferent input to the central nervous system. This effect includes certain muscle contractions in the cranio-cervical region, which have a high density of muscle spindles, thereby increasing the cervical range of motion (Röijezon et al., 2015).

Regarding ECRE, the current study's findings are consistent with those found in other studies (Pérez-Cabezas et al., 2020; Humphreys & Irgens, 2002; Balbaa & Ayad, 2006; Reddy et al., 2021). Pérez-Cabezas et al. (2020) conducted a randomized control trial to investigate the effect of ECRE plus traditional physical therapy on 44 patients with chronic neck pain (CNP) over 9 intervention sessions. The results showed that the ECRE group experienced a greater reduction in pain pressure threshold and an increase in cervical range of motion (ROM) in all movement directions compared to the traditional physical therapy program alone. Humphreys & Irgens (2002) revealed a positive effect of eye-head coordination exercises on reducing pain intensity and enhancing the disability of cervical muscles in CNP patients. However, their findings were based on a small sample size (28 patients) and the execution of ECRE as a home-based program without therapist supervision, and they did not measure exercise adherence.

Balbaa & Ayad (2006) investigated the effect of an eye-head coordination rehabilitation program in CNP patients. Their findings showed a statistically significant reduction in the scores of the neck pain and disability scale in both groups, with a greater reduction in the experimental group. However, the study's results were based on a small sample size (40 patients). Furthermore, Reddy et al. (2021) investigated the effectiveness of eye-head coordination exercises versus isometric strengthening exercises in patients with CNP. The eye-head coordination exercises group revealed significant improvements in terms of decreased cervical disability and pain intensity compared to the control group. However, this study was limited by the execution of ECRE as a home-based program without therapist supervision, and they did not measure exercise adherence.

Furthermore, the current study findings were dissimilar to those of other studies (Lluch et al., 2013; Bobos et al., 2016). Lluch et al. (2013) showed no significant effects of the cervical re-education program on cervical pain. The different study design (single-group design), small sample size (30 patients), and the execution of cervical re-education exercises without eye rehabilitation exercises could explain the contrast with our study. Additionally, their findings were based on a within-group impact with no comparison to a control group. Bobos et al. (2016) revealed that the cervical re-education approach had no impact on cervical musculature pain in CNP patients. However, the reasons for these conflicting results may include the different study design (single-group design), recruiting healthy subjects, and executing cervical re-education exercises only without eye rehabilitation. Similar to Lluch et al., their findings were based on a within-group impact with no comparison to a control group.

Regarding MIT, our current study findings revealed a superior effect of the MIT program over traditional physical therapy alone in terms of cervical function, cervical ROM, and pain intensity level in CNP patients. The mechanism by which MIT induced this effect could be explained by the fact that the motor imagery therapy program contributes to increasing the level of cortical excitability. Therefore, the neurological mechanisms underlying pain control by cortico-thalamic networks, as well as changes in neural plasticity, are related to cortical excitability (Zangrando et al., 2014). Induced changes in neural plasticity might explain the improvement in cervical ROM and the decrease in pain intensity level after MIT training. Thus, the reduction in pain intensity and enhancement of cervical ROM in patients with CNP after MIT training interventions may reduce disability (Hardwick et al., 2018).

The current study's findings concerted with those found in other studies, (ÖZCAN et al., 2019; Park et al., 2017; Javdaneh et al., 2021; de-la-Puente-Ranea et al., 2016). A randomized single-blind clinical trial conducted by ÖZCAN et al., (2019) compared the effect of motor imagery therapy program versus conventional physical therapy in 40 patients with CNP. Motor imagery therapy training contributes to reduction in the level of pain intensity and enhancing cervical function. However, that study was limited to a small average of ages (18- 22 years). Park et al. (2017) found a positive effect of combined action observation training with strengthening exercises on cervical function, pain intensity level and cervical ROM than strengthening exercise alone in patients with CNP. However, that study findings were dependent on small sample size (N=30) and execution one phase only of MIT program (action observation phase).

Furthermore, Javdaneh et al. (2021) compared the effectiveness of motor imagery therapy versus neck stabilization exercises in CNP patients. Patients were randomly assigned into three groups (N=72). First group received neck stabilization exercises alone, second group received combined exercise group (neck stabilization exercises plus MIT program) and third group received care advices only. The results revealed the superiority of motor imagery therapy group over neck stabilization exercises group and control group in enhancing of the cervical pain intensity level and disability. Furthermore, de-la-Puente-Ranea et al. (2016) revealed a positive effect of action observation approach in cervical ROM and the level of pain in CNP patients. However, that study findings dependent on execution a single session only of the intervention, small sample size (N=28) and using one phase only of MIT (action observation phase).

On the contrary, results obtained in our present study considering enhancement of cervical range of motion do not align with the findings with Morales Tejera et al. (2020) who investigated the effect of motor imagery training, action observation training and therapeutic exercises on pain modulation in the cervical spine. This contradiction may be because of both motor imagery phase and action observation phase have investigated in healthy subjects and execution a single session only of the intervention. However, that study findings were dependent on a within-group impact with no comparison to control group.

5. LIMITATIONS

The current study was constrained by a small sample size; hence, the results need to be thoroughly evaluated in a larger population. Additionally, a follow-up assessment was not conducted, and the treatment only lasted four weeks, which is a short period. As a result, future research should investigate the long-term effects of the intervention and include follow-up assessments. Furthermore, due to the nature of the trial, it was impossible to blind the therapist or the patients.

6. CONCLUSIONS

Adding ECRE exercises or MIT to a conventional physical therapy program led to notable improvements. ECRE exercises, in particular, were more effective in reducing pain, enhancing cervical ROM, and decreasing functional disability compared to the conventional therapy program alone in patients with CNP. ECRE and MIT can be safely applied to patients with CNP. They may also have additional benefits, such as improving patient adherence to the rehabilitation process. Moreover, these exercises should be considered for inclusion in the rehabilitation of CNP patients due to their ease of execution and low cost in clinical practice.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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