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EFFICACY OF ENDURANCE TRAINING ON DEEP CERVICAL FLEXOR MUSCLES USING PRESSURE FEEDBACK IN MECHANICAL NECK PAIN

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ABSTRACT

Background: Mechanical neck pain is most prevalent in middle age and a common condition affecting 22 % to 70% of the general population. While the exact aetiology of the pain is unknown, most of the mechanical pain is due to mechanical factors such as sprains and strains of the neck muscles or ligaments.

Methods: 60 subjects (male 33, female 27) with mechanical neck pain who fulfilled the inclusion criteria were chosen. After baseline evaluation of history, NPRS, cervical range of motion and Deep Cervical Flexor Endurance (DCF), the subjects were allocated into three groups which received DCF training by modifying the use of pressure biofeedback. Group 1 received DCF Training with Visual Pressure Biofeedback 10 repetition for three sets. Group 2 received DCF training without Visual Pressure Biofeedback 10 repetition three sets. And Group 3 received DCF training with Pressure Biofeedback (without visual input) 3 set of 10 repetitions. After 15 days of intervention, post-intervention measures of the variables were obtained.

Results: Data were analyzed using SPSS 1 version. Between-group analyses showed that subjects in Group 1 have a statistically and clinically significant improvement (p-value < .005), pain (NPRS), cervical ROM, DCF endurance and Neck Disability Index when compared to the Group 2 and 3. The pre and post values for all the three groups within the group analysis showed a statistical and clinically significant difference.

Conclusion: Deep Cervical Flexor Training with Visual Pressure Biofeedback provides better clinical improvement in terms of pain reduction, cervical flexion and extension ROM, DCF endurance, and Neck Disability Index score.

Keywords: mechanical neck pain, deep cervical flexor training, bubble inclinometer, range of motion.

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INTRODUCTION

Neck pain and associated impairments increase with age. Females are most commonly affected. Majority of the mechanical neck pains are due to factors such as sprains and strains of the muscles or ligaments of the neck.

Mechanical pain is described as a non-specific pain of the cervicothoracic region. The pain is caused by abnormal stress or strain on the muscles of the vertebral column and is further aggravated by neck movements. [1].

The prevalence of neck pain in 2010 was said to be 4.9% of the global population. Of which females were 5.8 %, and males were 4.0%. The disability encountered by the general population due to neck pain ranged from 2% to 11%. The working population reported 11% to 14% of limitation in their activities because of neck pain [2].

Anatomical structures in the cervical region such as the zygapophyseal joints, vertebral endplates, muscles, ligaments, neural structures, and the intervertebral disc can be a source due to which mechanical neck pain are triggered. However, the evidence is lacking to support the hypothesis that these pathoanatomical features are a primary source of mechanical neck pain.

According to the ICD (International Statistical Classification of Disease and Related Health Problems) and ICF (International Classification of Function), a diagnosis of sprain and strain of neck associated with movement coordination impairments is made when the patient presents with Neck pain (duration >12 weeks), Less coordination, strength and endurance of neck and upper quarter muscles, Less Flexibility in the upper quarter muscles, ineffective repetitive task performance, below standard performance in the cranial cervical flexion test, below standard performance in the the deep flexor endurance test [3].

The proper postural alignment of the head on the neck is maintained by the Deep Cervical Flexor muscles (DCF). Impaired DCF function disrupts the balance between anterior and posterior neck stabilizers leading to a faulty posture, which contributes to cervical impairment. Hence training the deep neck flexor to improve the balance between the postural muscles has become very imperative [4].

The endurance of the deep cervical flexor is measured clinically by performing a Cranio Cervical Flexion Test (CCFT). The endurance is measured using an established protocol by using a pressure biofeedback unit. The Endurance of DCF was defined as the maximum time that subjects could maintain a base pushing pressure higher than 50 mmHg [5].

Eight patient-reported outcome measures to assess the disability caused due to neck pain was systematically analyzed in 2012. This study concluded that the neck disability index (NDI) was the most extensively studied tool with good validity and moderate reliability. The tool has been translated into many languages and is recommended for practical use [6,7].

A quality review, by Williams et al. 2010, concludes that a

single inclinometer method with the Spin-T goniometer is an excellent reliable and valid tool to measure the cervical range of motion (CROM) [8,9].

Based on past literature search, it is noted that a comparison of endurance training has not been carried out with outcomes above. Therefore, the intent of the present study was to check the efficacy of endurance training on deep cervical flexor in comparison to a visual input variation and pressure biofeedback unit. To assess the endurance of deep cervical flexor muscles in a patient with mechanical neck pain, using pressure feedback. In the past study, it reveals that deep cervical flexor training has not been carried out with and without visual feedback.

METHODOLOGY

Institutional Ethical Committee approved the proposed study, Sri Ramachandra Medical College and Research Institute, (Deemed to be University)

IEC Number: REF: CSP/17/OCT/61/286

Research Design: Quasi-Experimental study (pre-post design)

Study Setting and Duration: Patient referred to Physiotherapy Outpatient Department, Sri Ramachandra Hospital, Chennai from orthopedic units were recruited. The study had started in December 2017 and completed by April 2018 with 15 days follow up for all participants

Tools used: Pressure Biofeedback unit, Bubble inclinometer

Procedure: Patients with the chief complaints of neck pain were recruited for the study after obtaining informed consent for participation. A Total of 60 samples (n=60) were recruited adhering to the inclusion and exclusion criteria. The patients were allocated into Group 1, 2, and 3. Before starting the intervention, an intake evaluation was performed, and baseline values of pain Score, Cervical Range of Motion, Deep Cervical Flexor Endurance and Neck Disability Index was measured.

Numerical pain rating scale: An alternate version of a visual analog scale with a horizontal line and the segmented numeric value is called the Numeric pain rating scale. The patient is asked to select a number between 0-10, which best reflects the intensity of their pain [10].

Cervical range of motion (CROM): Cervical ROM (active) in flexion and extension was measured for each subject. The subjects were positioned comfortably, and the neck is exposed. The subjects are given a clear demonstration of the neck movement, which needs to be performed [11].

FLEXION AND EXTENSION

Test Position: Chair sitting with the thoracic and lumbar spine supported by the back of the chair. Neck in neutral, with no degree of rotation or lateral flexion.

Test Procedure: The ROM in degrees was measured for cervical flexion and extension. The subjects performed neck flexion by doing a chin tuck, which is then followed by bending the neck forward until their movement is re-

stricted by tightness or discomfort. The normal range of cervical flexion averages to around 0-50 degrees.

Neck extension was measured when the subject first lifted their chin and moved their head up until their movement is restricted by tightness or discomfort the normal range of cervical extension averages to around 0-60 degrees [8].

CRANIOCERVICAL FLEXION TEST (CCFT):

Patient position: supine lying with the neck in neutral without any pillows.

Procedure: the uninflated pressure sensor was placed under the arch of the neck so that it touches the occiput. The sensor is inflated to a standard pressure of 20mmHg, so as not to increase neck lordosis. The uninflated pressure sensor was placed in the arch of the neck so that it touches the occiput and is inflated to a stable baseline pressure of 20 mm Hg; this represents a standard pressure sufficient enough to fill the space between the testing surface and the neck but does not increase the lordosis. The patient was instructed to perform the head nodding action slowly and gently.

The progressive inner range activation of deep cervical flexor was assessed by asking the patient to increase the pressure on the sensor by 2mmHg by pressing down on the sensor (nodding) for three consecutive attempts.

The endurance of deep cervical flexor was assessed by asking the patient to increase the pressure by 2mmHg and to hold the pressure [12,13,14].

Neck disability index: The ten items in the questionnaire are scored from 0-5 and give us a quantitative value of the disability encountered by the patient due to their neck pain.

Intervention: After collecting the baseline parameters, the subjects were divided into three groups and received Deep Cervical Flexor training by modifying the use of pressure biofeedback.

Group 1: received Deep Cervical Flexor training with Visual Pressure Biofeedback;

Group 2: received Deep Cervical Flexor training without Visual Pressure Biofeedback;

Group 3: received Deep Cervical Flexor training with Pressure Biofeedback (without visual input),

The duration of intervention was 15 days, followed by which post-intervention measures of the variables were obtained. The data obtained were subjected to statistical analysis using SPSS (version -17).

Deep cervical flexor training: Deep cervical flexor training was done by performing cranio-cervical flexion movement, which activates the deep flexors of the upper cervical region, and statically holding the movement to improve its endurance [15,16].

Deep cervical flexor training without visual pressure feedback: A towel roll was placed behind the neck of the patient. Cranio-cervical flexion movement was taught to the patient to increase the activation of deep cervical flexors, which was repeated for ten times of 3 sets. To improve

the endurance of deep cervical flexor, they were taught to maintain that range for 30 seconds.

Deep cervical flexor training with visual pressure feedback: A pressure sensor which was inflated to 20mmHg was placed behind the neck of the patients, and the dial which is connected to the pressure sensor was given to the patient. The deep neck flexor activation was initiated by performing cranio-cervical flexion, which increases the pressure in the sensor, which is indicated by the movement of the dial. The patient was asked to increase the pressure by 2mmHg and hold the pressure for 30 seconds and repeat for ten times for three sets.

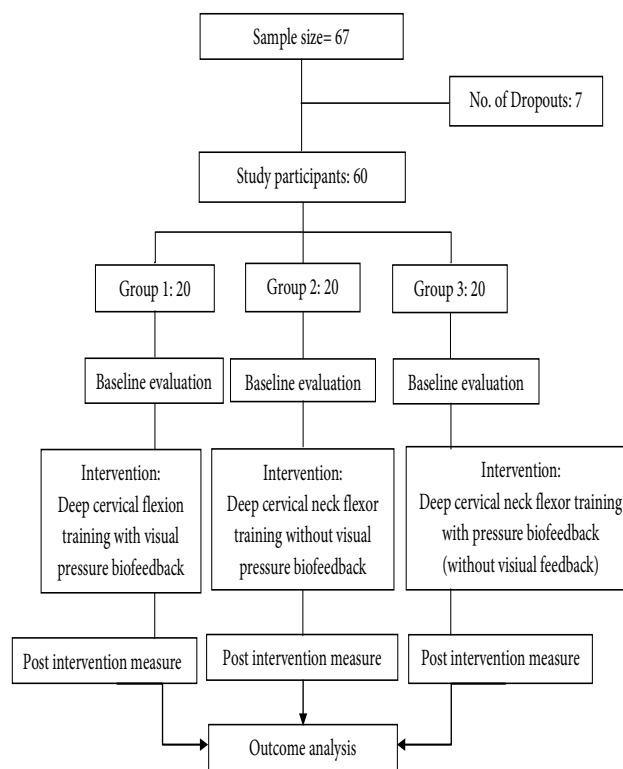
Deep cervical flexor training with pressure biofeedback without visual input:

A pressure sensor which is inflated to 20mmHg was placed behind the neck of the patients, and the dial, which is connected to the pressure sensor, was held by the therapist. The therapist instructs the patient to perform cranio-cervical flexion, which increases the pressure in the sensor, which is indicated by the movement of the dial. Once the required increase in pressure is achieved, the therapist asked the patient to hold the contraction for 30 seconds. The patients repeated this ten times and three sets.

DATA ANALYSIS

The descriptive statistics, percentage analysis, was used for categorical variables, and mean and S.D was used for continuous variables. The analysis of skewed data between the groups was done by “Mann Whitney U” test. “Paired t” test was used to analyze the variables the within group, except pain. Whereas, the Wilcoxon Signed Ranks test was used to analyze within the group NPRS Score. The statistical tests were considered significant when the p-value was less than 0.05.

Illustration 1: Consort flowchart



RESULTS

A total of 60 subjects were included in the study, and all subjects had completed the follow up at two weeks. The demographic characteristics of all the groups are outlined in Table 1. The number of males and females included in each group were similar.

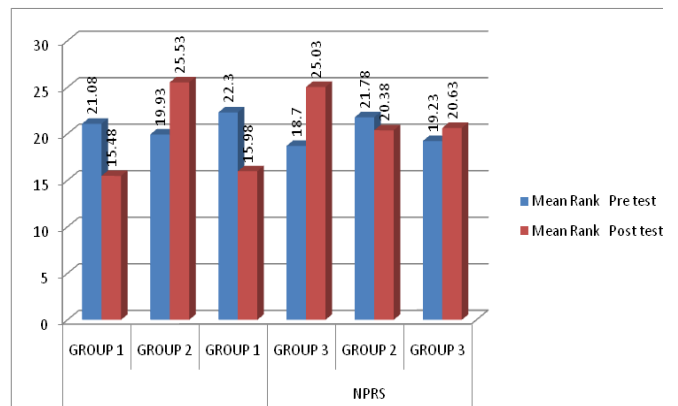
Table 1: Demographical Data

Variables		Group 1	Group 2	Group 3
Age Mean (SD)		32.55(5.8)	32.85(5.5)	32.90(5.1)
Gender	Male	10(50%)	11(55%)	12(60%)
	Female	10(50%)	9(45%)	8(40%)

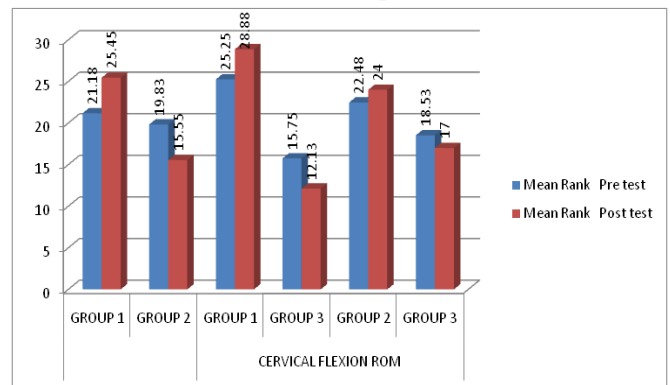
Table 2: Comparison of Variables between the Groups

Variables		Mean Rank		p-value
		Pre-test	Post-test	
NPRS	GROUP 1	21.08	15.48	.004
	GROUP 2	19.93	25.53	
	GROUP 1	22.30	15.98	
	GROUP 3	18.7	25.03	.010
	GROUP 2	21.78	20.38	.944
	GROUP 3	19.23	20.63	
CERVICAL FLEXION ROM	GROUP 1	21.18	25.45	.005
	GROUP 2	19.83	15.55	
	GROUP 1	25.25	28.88	
	GROUP 3	15.75	12.13	.000
	GROUP 2	22.48	24.00	.057
	GROUP 3	18.53	17	
CERVICAL EXTENSION ROM	GROUP 1	17.43	23.45	.095
	GROUP 2	23.58	17.55	
	GROUP 1	22.43	27.78	
	GROUP 3	18.58	13.23	.000
	GROUP 2	24.10	25.13	.012
	GROUP 3	16.90	15.88	
DCF ENDURANCE	GROUP 1	20.88	24.50	.030
	GROUP 2	20.13	16.50	
	GROUP 1	24.88	27.23	
	GROUP 3	16.13	13.78	.000
	GROUP 2	23.50	23.78	.076
	GROUP 3	17.50	17.23	
NDI	GROUP 1	20.15	13.65	.000
	GROUP 2	20.85	27.35	
	GROUP 1	21.48	12.13	
	GROUP 3	19.53	28.88	.000
	GROUP 2	22.00	16.15	.018
	GROUP 3	19.00	24.85	

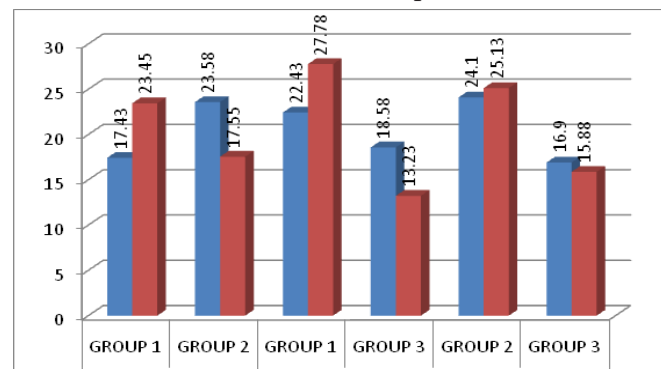
Graph 1: Comparison of NPRS between the Groups



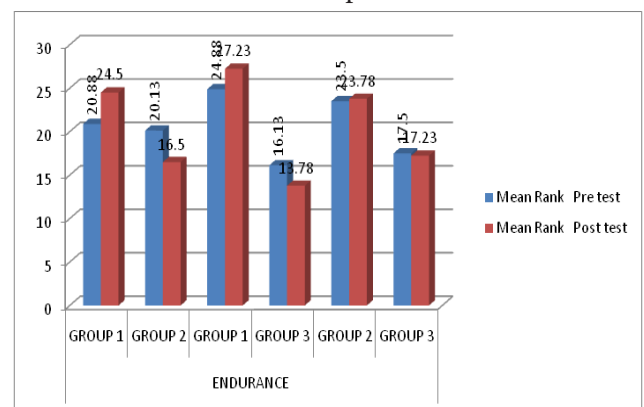
Graph 2: Comparison of cervical flexion ROM between the Groups



Graph 3: Comparison of cervical extension ROM between the Groups



Graph 4: Comparison of DCF Endurance between the Groups



Graph 5: Comparison of NDI between the groups

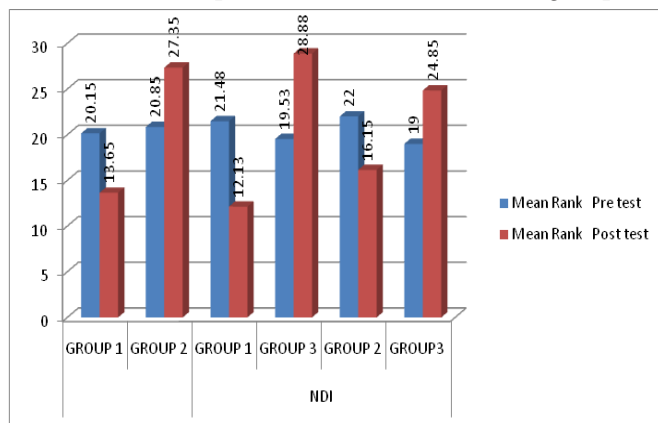


Table 3: Comparison of Pain (NPRS) within groups

Groups	N	Pain –pre and post-test(Mean Rank)	p-value
Group 1	20	10.50	<.001
Group 2	20	10.50	<.001
Group 3	20	10.50	<.001

NPRS-Numerical Pain Rating Scale

Wilcoxon Signed Ranks Test,

Table 3 shows comparison of pain reduction within groups. All the three groups statistically Significant ($p < .001$) in pain reduction.

Table 4: Comparison of Cervical ROM, DCF Endurance, and NDI within Groups.

Variables	Group 1		Group 2		Group 3		p- value
	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post test	
Cervical flexion Mean (SD)	41.95 (4.8)	48.10 (3.8)	41.05 (6.6)	43.80 (5.9)	39.00 (3.7)	40.45 (4.1)	<.001
Cervical extension Mean (SD)	49.80 (3.4)	57.60 (3.3)	51.20 (4.)	55.35 (4.)	49.60 (3.0)	52.40 (3.)	<.001
DCF endurance Mean (SD)	27.51 (2.4)	32.39 (5.0)	27.42 (3.3)	28.70 (3.)	26.05 (3.5)	27.00 (3.8)	<.001
NDI Mean (SD)	15.75 (5.2)	2.90 (2.9)	15.90 (4.5)	6.75 (3.3)	14.65 (3.5)	9.85 (4.1)	<.001

DCF-Deep Cervical Flexors, NDI-Neck Disability Index; SD-Standard Deviation

Paired t-Test, Significance $p < .001$

Table 4 shows a comparison of cervical ROM, DCF endurance, and NDI within the groups. All the three groups show statistical significance ($p = <.001$) for the cervical ROM (Flexion and Extension), DCF endurance, and NDI Score.

Table 5: Analysis of Variables between the Groups

Variables	Group	Pre-test Mean (SD)	Post-test Mean (SD)	f value	p-value
NPRS	Group 1	6.30(1.12)	1.55(.75)	6.084	.004
	Group 2	6.25(1.11)	2.60(1.18)		
	Group 3	5.90(1.16)	2.65(1.34)		
Cervical flexion	Group 1	41.95(4.89)	48.10(3.85)	13.201	.000
	Group 2	41.05(6.61)	43.80(5.91)		
	Group 3	39.00(3.79)	40.45(4.12)		

Cervical extension	Group 1	49.80(3.4)	57.60(3.3)	9.120	.000
	Group 2	51.20(4.8)	55.35(4.7)		
	Group 3	49.60(3.0)	52.40(3.2)		
DCF Endurance	Group 1	27.51(2.4)	32.39(5.0)	8.835	.000
	Group 2	27.42(3.3)	28.70(3.3)		
	Group 3	26.05(3.5)	27.00(3.8)		
NDI	Group 1	15.75(5.2)	2.90(2.9)	19.572	.000
	Group 2	15.90(4.5)	6.75(3.3)		
	Group 3	14.65(3.5)	9.85(4.1)		

NPRS-Numerical Pain Rating Scale, DCF-Deep Cervical Flexors, NDI-Neck Disability Index;

ANOVA

Table 5 shows the between-group analysis of all the three Groups variables. Statistically significant improvement were observed in pain reduction (NPRS) – ($p\text{-value} = <.004$), Cervical flexion ROM ($p\text{-value} = <.000$), Cervical extension ROM- ($p\text{-value} = <.000$), DCF endurance ($p\text{-value} = <.000$), NDI ($p\text{-value} = <.000$).

DISCUSSION

Neck pain is a chronic disorder and adds to economic burden to the society. Altered motor control of the cervical spine and its associated micro and macro trauma of the cervical structure may be a mechanical contributing factor for recurrent neck pain. [17].

Altered mechanics of deep cervical flexor muscle is observed in patients with neck pain when they perform Cranio-cervical flexion test. Hence restoration of muscle functions becomes an integral part of the treatment of neck pain [5]. So far, no studies are comparing the deep cervical flexor training with and without visual feedback.

We have identified that the prime cause of mechanical neck pain is less endurance of cervical flexor muscle. Following the training for deep cervical flexor muscle, most patients improved. This study was designed to find the effectiveness of visual input of DCF training with pressure biofeedback in mechanical neck pain.

A similar study has been conducted on pressure bio-feedback guided deep cervical flexor training along with conventional therapy in mechanical neck pain. Exercise including stretching of sternocleidomastoid muscle, upper trapezius, levator scapulae, trapezius for ten participants. The study concluded that deep cervical flexor with biofeedback was effective than the conventional group. The intergroup comparison showed a statistically significant difference in muscle performance ($p = <.001$) and pain intensities ($p = <0.004$) [18].

An analysis of outcomes within the groups was done using t-test, Wilcoxon signed rank test, and the observations of the present study were as follows:

The post-intervention data of NPRS for Group 1 reveals. A similarly a 58% reduction of the symptom (pain) in Group 2 and a 55% reduction of symptoms (pain) in Group 3. The post-intervention outcomes of NPRS reveal that Group 1 had a more significant proportion of improvement, as compared to the other two groups. This outcome is matched to

the study outcome of Aquino et al., [19].

As for as cervical ROM concluded, the post-intervention data of Group 1 had significant 14.6% improvement of cervical flexion ROM, against 6.6% and 8.1% improvement for group 2 and 3 respectively. The outcome for ROM reveals a higher proportion of improvement among group 1 patients.

The post endurance training data of DCF endurance for groups 1, 2 and 3 were 17%, 4.8% and 3.6% improvement as compared before training yet again group 1 had a significant proportion of improvement. Dong Yeon Kang et al., had a similar outcome, which favors the present study outcome for group 1 [20].

The NDI for Group 1, post-intervention data reveals a significant 81% reduction of disability, as compared to pre-intervention. The NDI for Group 2, post-intervention data showed a significant 57.5 % reduction of disability, as compared to pre-intervention. The NDI for Group 3, post-intervention data showed a significant 32.7 % reduction of disability, as compared to pre-intervention. This outcome is matched to the study of Enrique Lluch et al., [21].

The analysis of the outcomes mentioned above may be inferred that the comparison of outcome variables had an improvement for all three study groups, although a relative difference existed between the groups.

An analysis of outcomes between the groups was done using the Mann-Whitney U test.

The post intervention analysis between the Groups 1 & 2, Groups 1 & 3 and Groups 2 & 3, shows that, there is significant reduction in the pain intensity of groups 1&2 ($p < .004$), Compared to groups 2 & 3 ($p = < .944$) and groups 1 & 2 ($p = < .010$) respectively.

This correlates with the study conducted by Nezamuddin et al.,. Which states that the pain intensity between the pressure biofeedback guided DCF training, and only conventional therapy was significant ($p = .004$).

The post intervention analysis between the Groups 1 & 2, Groups 1 & 3 and Groups 2 & 3, shows that, there is significant improvement in the cervical flexion ($p < .000$) and extension ($p = .000$) in groups 1 & 3, compared to Group 2 & 3 ($p < .057$), ($p < .012$) and Group 1 & 2 ($p < .005$), ($p < .095$).

There was a significant improvement in DCF endurance in Group 1 & 3 ($p < .000$) than groups 1 & 2 and Groups 2 & 3. The muscle performance was a statistically significant among the pressure bio-feedback group than the control group. This finding was similar to a study by Nezamuddin et al..

The post intervention analysis between the Groups 1 & 2, Groups 1 & 3 and Groups 2 & 3, shows that, there was significant reduction in the NDI score of groups 1 & 2 ($p < .000$), and 1 & 3 ($p < .000$) and groups 2 & 3 ($p < .018$) respectively.

Between-group analysis of Group 1 with that of Group 2 and Group 3 shows that all the outcomes variables such

as pain intensity, cervical flexion, and extension ROM, DCF endurance and neck disability index score of Group 1 shown to have a high degree of significance than groups 2 and 3.

These significances can be contributed to the fact by Basmajian, (1963) that the subject could control the recruitment as well as the frequency of discharge of motor units through auditory and visual feedback [22]. Similarly, the finding of way et al. (1986) suggests that increased muscle strength is associated with the use of feedback. Nezamuddin et al. (2013) concluded that adjunctive therapy of pressure biofeedback was an effective means of reducing pain [18]. The Present study shows the visual feedback aided DCF training had an improvement of outcomes in all the four variables, among all the three groups.

Clinical Implication: The observations of the present study reveal that patients belonging to Group 1 had significant clinical and statistical improvement. Hence, it may be inferred that for patients with mechanical neck pain, the treatment regimen should include Deep Cervical Flexor training with Visual Pressure Biofeedback. This may bring about a better clinical outcome and hence, functional status of the neck.

CONCLUSION

Deep Cervical Flexor training with Visual Pressure Biofeedback provides better clinical improvement in terms of pain, cervical flexion, extension ROM, DCF endurance, and NDI score. The future studies may focus upon the long term effects of such training program and preventing a recurrence.

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