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Effectiveness of Cervical Proprioception Training versus Deep Cervical Extensor Training on Cervical Extensor Endurance in Patients with Chronic Non- Specific Neck Pain

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ABSTRACT

Background: Chronic neck pain (CNP) is characterized as persisting pain for more than 3 months, which has a longer expected recovery time, and is one of the individuals most common and debilitating problem. CNP has been linked to abnormalities in cervical proprioception and neck extensor endurance (NEE), two processes that are essential for preserving cervical spine function. Neck pain itself has a clear role in proprioception and neck sensorimotor control, and subsequently influence orientation. The cervical extensor muscles are considered equally important in the recovery of patients with neck pain. Cervical Proprioception Training (CPT) may have the added advantage of facilitating the deep cervical extensor muscles.

Objective: To compare the effectiveness of Cervical Proprioception Training (CPT) versusDeep Cervical Extensor Training (DCET) in patients with chronic non- specific neck pain.

Methods: This was a non-randomized clinical trial that was quasi-experimental in nature. The study population included factory workers in Penang patients of both sexes, aged between 30 and 50 years, diagnosed by GP with a chronic non-specific neck pain for 3 months or more. Two experimental groups, group 1 received Cervical Proprioception Training and while group 2 received Deep Cervical Extensor Training for a duration of 6 weeks. The study included a pre and post intervention assessment of muscle endurance, functional status and pain, using validated measurement tools such as the Cervical Extensor Endurance Test (CEET) , Neck Disability Index (NDI) and Visual Analogue Scale (VAS).

Results: Following 6 weeks, concerning VAS there was a statistically significant decline of VAS in the two groups with favor to the CPT group ($p < 0.05$) in comparison with the DCET group. In regards to the NDI levels, there was a statistically significant decline in NDI scores in the two groups with favor to the CPT group (mean decline of 13.48) in comparison with the DCET group (mean decline of 10.17). Concerning CEET levels there was a statistically significant improvement in CEET scores ($p< 0.05$) in the two groups with favor to the DCET group in comparison with the CPT group.

Conclusion: Both groups of patients with chronic non-specific neck pain (CNNP) demonstrated similar outcomes. Both groups were found to reduce pain levels, as assessed using VAS, and enhance functional status, as evaluated using NDI and improve NEE as measured by CEET .The present study also provided evidence to support the idea that Cervical Proprioception Training and Deep Cervical Extensor Training lead to improvements in cervical extensor endurance, as measured by CEET.

Keywords: Neck Pain, Proprioception, Muscle, Functional Status, Visual Analogue Scale, Chronic, Chronic Neck Pain, Cervical Spine

INTRODUCTION

The prevalence of neck pain is such that by 2050, the anticipated global incidence of neck pain cases is expected to reach 269 million, reflecting a 32.5% rise from 2020 to 2050, one of the most usually occurring musculoskeletal disorders.[1] The Neck Discomfort Task Force defined the anatomical region of the neck as the cervical spine and the muscles and soft tissues around it, whether or not they cause discomfort to the head, trunk, or shoulders.[2] Among the most prevalent and incapacitating conditions affecting people is Chronic Neck Pain (CNP), which is defined as pain that persists more than three months and requires a longer estimated recovery period. . A diagnosis of "non-specific" neck pain (NSNP) can be made solely based on clinical evidence, provided that there are no features that imply a more severe condition and/or a specific underlying

disease that is causing the pain.[3]The majority of guidelines for diagnosing and treating neck pain suggest that the best evidence-based physiotherapy therapies for treating people experiencing neck pain call for a combination of education, exercise, and manual therapy.[4]

The cervical muscle spindles play a crucial role as proprioceptors in the neck, Modifications in the operation of the cervical muscles have an impact on cervical proprioception by modifying the release of muscle spindles.[5] Chronic pain has the ability to modify the sensitivity of the muscle spindle receptors and disrupt the incoming proprioceptive signals. Diminished proprioception has been linked to reduced engagement in the deep muscle group, which encompasses the proprioceptive network .[6] Neck muscle fatigue causes changes in the sensitivity of sensory receptors and muscle spindles, which in turn affects the input of proprioceptive information to the higher centers of the body.[7] Neck-based cervical proprioception is essential for maintaining postural stability, synchronizing head movements, and guaranteeing ideal spatial awareness .[8] Previous study demonstrated that individuals with CNP exhibited impaired cervical proprioception in comparison to those who were asymptomatic. which signifies the strong correlation between neck pain and cervical proprioception.[9] Therefore, engaging in proprioceptive exercises that target the restoration of the muscular tone in the deep neck muscles can be a successful approach to alleviate pain and enhance both the range of motion and functional limitations .[10]

The Deep Neck Extensors (DCE) contribute to maintaining the cervical lordosis, by working together with the deep neck flexors and preventing the head from tilting forward. Patients with neck pain are thought to benefit equally from strengthening their cervical extensor muscles highlighting the significance of exercise in enhancing function .[11] When comparing the deep cervical extensors of neck pain patients to those of healthy controls, structural alterations have been noted, which imply that patients with neck pain may exhibit different deep extensor behavior .[12] CNP has been linked to abnormalities in cervical proprioception and Neck Extensor Endurance (NEE), two processes that are essential for preserving function of the cervical spine. In comparison to individuals who did not exhibit any symptoms, CNP subjects displayed reduced endurance capacity and poor proprioception .[13]

The relationship between neck muscle endurance and proprioception in people with chronic neck pain is insufficiently studied. The effectiveness of deep cervical extensor muscle training in comparison with cervical proprioception training remains also unclear. Thereby, this study aims to evaluate whether in patients with chronic non-specific neck pain, whether cervical proprioception training can have a positive impact on the neuromuscular control of the cervical region extensor muscles. The objective of the current study is to compare the effectiveness of cervical proprioception training versus deep cervical extensor training in patients with chronic non-specific neck pain on Neck Extensor Muscle Endurance, Neck Pain and Functional Status.

METHODOLOGY

All subjects were recruited from diverse private manufacturing workers in Penang (Malaysia) who had Chronic Non-Specific Neck pain. This study was conducted in a non-blinded manner, a quasi experimental clinical trial from May to July 2024. A total of 65 chronic non-specific neck pain patients were considered for eligibility in the current study. 60 eligible patients (women and men) ranging in age from 30 to 50 were divided equally into two groups by means of a convenience sampling method. The Cervical Proprioception Training group consisted of 15 males and 15 females, while the Deep Cervical Extensor Training group consisted of 16 males and 14 females. 5 subjects were eliminated as they did not meet inclusion criteria. The Ethical Committees of the AIMST University gave their permission to this study (Ref No: AUHEC/SOP/FAHP/05/07/2024).

Once the participant agreed to take part in the research, they were informed and obtained consent in the verbal and written form. They were also informed that they were allowed to withdraw from the study at any moment. Both workout regimens lasted for a duration of 6 weeks, with a frequency of 3 days each week. Prior to commencing the trial, baseline measurements were taken. Each session typically lasted for around 15 to 20 minutes. All the outcome measures were reassessed at the conclusion of the 6-week period. The participants were instructed to abstain from utilizing alternative therapies throughout the duration of the trial.

The inclusion criteria were as follows: patients of both sexes, age between 30 and 50 years, confirm diagnosed with chronic non-specific neck pain grade I and II (according to Task Force on Neck Pain classification Grade), a positive finding for weakness of the deep neck extensors (unable to sustain a chin tuck position in neutral for 20 seconds) measured through the Cervical Extensor Endurance Test (CEET), pain intensity of 1-7 on VAS score and scores mild or moderate disability (15- 24 points) or (10% - 48 %) in Neck Disability Index (NDI) score.

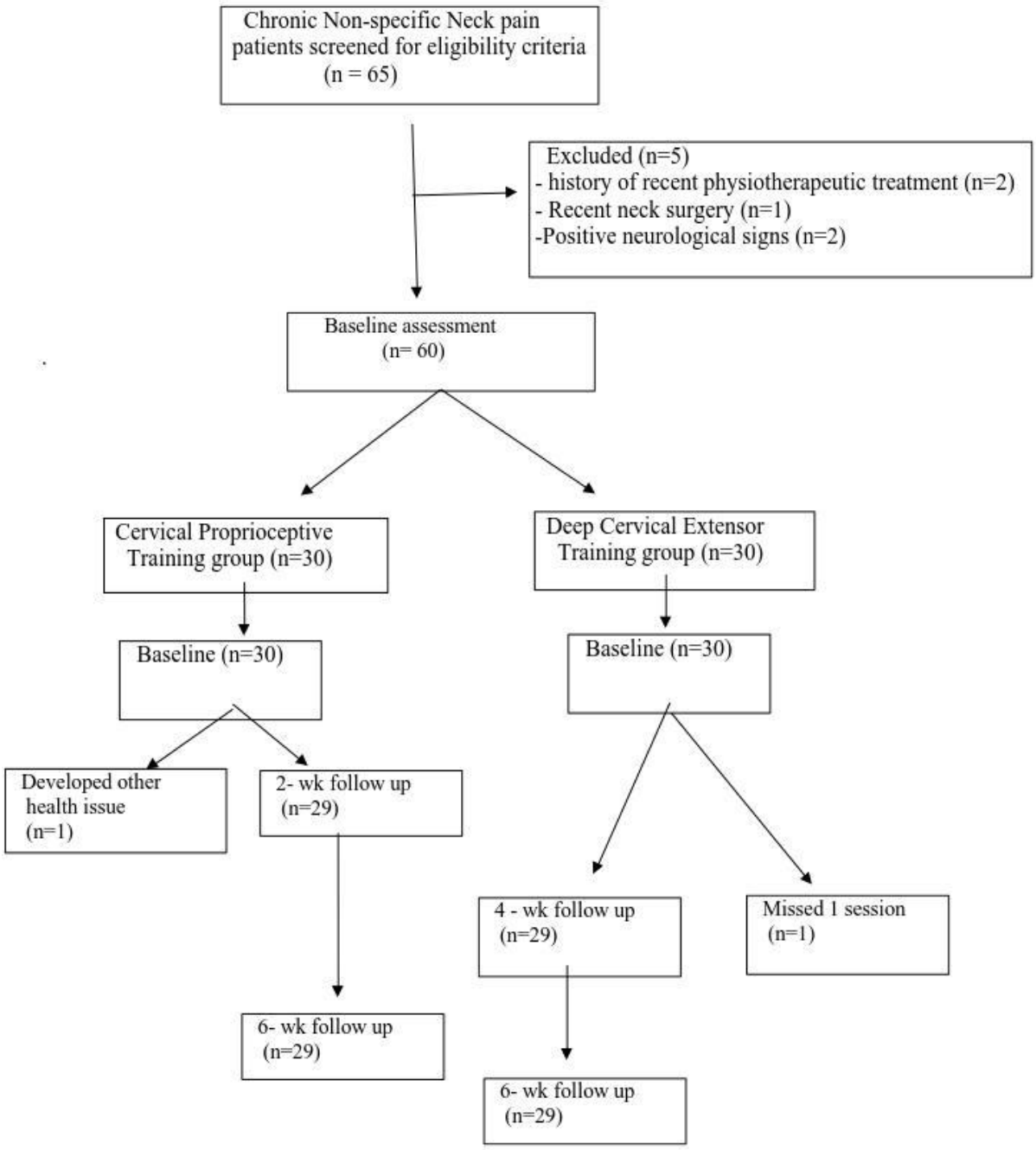

Figure 1.1 : Flow diagram of participants' recruitment and retention

Outcome Measures

Visual Analogue Scale (VAS)

Subjects used a visual analogue scale to rate their level of pain before the initial treatment. The pain intensity visual analogue scale (VAS) is a linear scale, typically 100 mm in length, with two descriptors indicating the highest and lowest levels of pain intensity (such as no pain and severe pain) at each end. The validity of the Visual Analogue Scale (VAS) for pain evaluation has been demonstrated in numerous studies to exhibit moderate to strong correlation.[14]

Neck Disability Index (NDI)

The participants' neck functions were determined using the English version of the Neck Disability Index (NDI) questionnaire. Ten items on a functional status questionnaire tailored to the patient's condition were completed; these included questions about pain, personal care, lifting, reading, headaches, focus, job, driving, sleeping, and recreation.. The scoring for each question is based on a scale of zero to five. The standards for interpreting the result are as follows: 0–4 points (0–8%) = no disability; 5–14 points (10–28%)= mild disability; and 15–24 points (30–48%) = moderate disability; 25–34 points (50–64%) for severe disability; 35–50 points (70–100%)

for total impairment .[15] The NDI is a valid, responsive, and dependable tool for measuring functional limitations in individuals with neck discomfort.[16]

Cervical Extensor Endurance Test (CEET)

The endurance of each participant to maintain a chin tuck posture,with the chin pulled in and the head held steady in a level position was evaluated. This was done in a prone position with the head and neck extended past the edge of the table, ensuring the cervicothoracic junction was supported. The timer was initiated at this moment, and the duration for which they could hold the position was measured in seconds. Participants were instructed to keep their heads stationary and to gaze directly at the ground below . A positive finding is also the inability of the individual to sustain a chin tuck position in neutral or to sustain a holding time of 20 seconds. The test would also be terminated if the head was moved into either flexion or extension.[17]

Interventions

Cervical Proprioception Training (CPT)

The components of Cervical Proprioception Training (CPT) that are considered to be relevant have been adapted here. Oculomotor control exercises, also known as gaze stability exercises, eye-head coordination exercises, and head relocation practice were all included in this regimen. Each regimen conducted involved performing 3 sets of 5 repetitions, thrice each week for a duration of 6 weeks, under the supervision of the therapist.

Oculomotor control (gaze stability) exercises

During weeks 1 and 2, the patients' eyes tracked a target (pen) on the outstretched palmof the therapist at a slow speed, while the head remained motionless in either a vertical or horizontal position. During weeks 3 and 4, the task required moving the head while keeping the eyes fixed on a target, either vertically or horizontally. During weeks 5 and 6, the eyes and head coordinated their movements to focus on an object (pen), either vertically or horizontally.[18]

Eye-head coordination exercises

The first exercise in eye-head coordination involved rotating the head and eyes to the same side, both left and right (Figure 1.2). Following that, patients were instructed to practice maintaining concentration on an object(pen) by following it with their eyes first and then their heads. After two weeks, there was still more development. The head moved after the eyes to look between two targets that were either vertically or horizontally positioned. Finally, around weeks five and six, the head and eyes turned in opposing left and right directions. By having patients remain upright,exercises were progressed by enhancing the pace and expanding the movements' scope .[19]

Head relocation practice

The patient was properly aligned facing a mirror in a seated position. After memorizing this mid position of the head-neck , they were instructed to carry out specific movements of the neck with their eyes closed. Without opening their eyes, the patient aimed to move back to the starting position. In other words, the patients attempted to reestablish their initial head position as closely as possible. This technique focused on analyzing the main movements of the cervical spine, such as, including flexion, extension, rotation, and lateral flexion.[20]

Fig 1.2 : Cervical Proprioception Training group: Eye-Head coordination exercise

Deep Cervical Extensor Training (DCET)

This technique aimed at prompting exclusive activation of the semispinalis cervicis. This was achieved by manually applying resistance at the C2 vertebral arch while participants, positioned upright, were instructed to exert backward pressure. Seated participants were assisted by a therapist who used her right thumb and forefinger to apply pressure, varying from gentle to more forceful, at the second cervical vertebra (C2) to encourage forward bending, while the left hand was used to hold the participant's left shoulder, ensuring any compensating movements could be monitored. Participants were instructed to exert their maximum voluntary force in the direction of extension, while ensuring that no neck pain was triggered (Figure 1.3). The workout programme involved maintaining resistance for a duration of 10 seconds, repeated ten times per set, and completing three sets per day. A 30-second interval was permitted between sets. Each participant engaged in this workout thrice weekly for a duration of 6 weeks under the guidance of a physical therapist.[21]

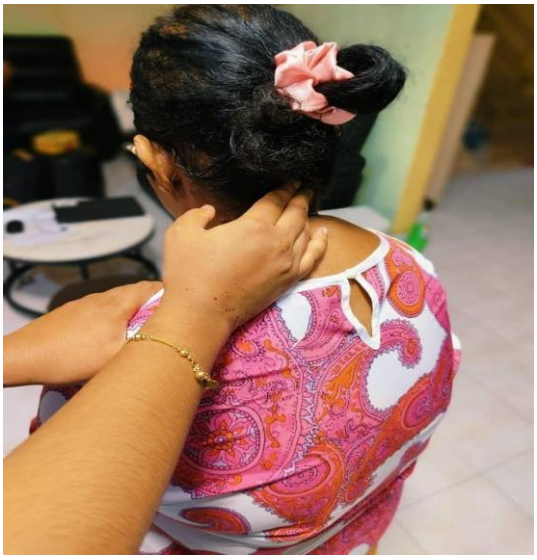

Fig 1.3: Hand positioning for the Deep Cervical Extensor Training group

RESULTS

The Shapiro-Wilk test was utilized to assess the normality of the variables of interest. The Paired Samples t-test was employed for comparing results within the same group, while the Independent Samples t-test was used for contrasting the dependent variables.(VAS, NDI, and CEET) between the two treatment groups (CPT and DCET) at both the baseline and sixth week of intervention.Demographic data for the remaining 58 subjects is presented in Table 1.1. The distribution of all quantitative variables was approximately normal. Ages are generally distributed evenly throughout the several categories, with no age group predominating in the sample of non-specific chronic neck pain. Thegender of the participants are distributed almost equally among the groups. The mean age of the participants was 38.4 ± 5.79 years old.

Visual Analogue Scale

Differences in pre and post intervention of CPT group are presented in Table 1.2. CPT group implied a significant difference in mean VAS score between baseline and six weeks later (5.21±1.37 vs. 2.93±1.53, $p < 0.05$) .Similarly, DCET group also implied statistically significant difference in mean VAS score between baseline and six weeks later (5.24 ±1.30 vs 3.00 ±1.60).

Neck Disability Index

In DCET group, NDI score of pre and post intervention measures showed statistically significant difference of mean values ranging from 33.97 ±8.34 vs 23.79±9.18) For CPT group, however, there was also better significant difference statistically in terms of mean values ranging from (36.72 ±10.73 vs 23.24 ±10.64) as compared with the DCET group. Analogous to VAS, inferences can be made that both groups produced comparable changes in NDI scores.

Cervical Extensor Endurance Test

The mean CEET scores of the participants in the DCET group were also significantly different at baseline and sixth-week (14.90 ± 2.92 vs 22.00 ± 4.81) of intervention. CEET scores of the DCET group depict a large gap in

terms of mean values in comparison with the CPT group. Compared with the CPT group, a significantly greater increase in CEET scores ($p< 0.05$) was observed in the DCET group which favored the DCET group.

Table 1.1: Baseline data of study samples

		n	%
Study group	Group 1	29	50.0
	Group 2	29	50.0
Gender	Male	29	50.0
	Female	29	50.0
	Mean (SD)		
Age			
<30	38.4 (5.79)	5	8.6
31-40		34	58.6
41-50		19	32.8

Note: SD: Standard Deviation; Group 1: Cervical Proprioception Training; Group 2: Deep Cervical Extensor Training

Between Group Analysis

Between-group comparison of patients' mean score of pain intensity (VAS scores), functional status (NDI scores), neck extensor muscle endurance (CEET scores) is outlined in fig (1.4). Concerning VAS there was a statistically significant decline of VAS in the two groups with favor to the CPT group in comparison with the DCET group . Concerning NDI levels there was a statistically significant decline in NDI scores in the two groups with favor to the CPT group (mean decline of 13.48) in comparison with the DCET group (mean decline of 10.17) .Concerning CEET levels there was a statistically significant improvement in CEET levels in the two groups with favor to the DCET group in comparison with CPT group . Thereby, it can be concluded that the null hypothesis is rejected and the alternative hypothesis is accepted.

Table 1.2 : Results of Visual Analogue Scale, Neck Disability Index and Cervical Extensor Endurance Test before and after intervention in group 1- Cervical Proprioception Training

	Mean (SD)	SEM	95% CI of the difference		t	P
VAS			**Lower**	**Upper**		
Pre-intervention	5.21 (1.37)	0.25	1.74	2.81	8.682	0.000
Post-intervention	2.93 (1.53)	0.28				
NDI						
Pre-intervention	36.72 (10.73)	1.99	10.29	16.67	8.662	0.000
Post-intervention	23.24 (10.64)	1.98				
CEET						
Pre-intervention	15.21 (2.80)	0.52	-4.63	-2.82	-8.395	0.000
Post-intervention	18.93 (4.00)	0.74				

Note: SD: Standard Deviation; SEM: Standard Error of Mean; CI: Confidence Interval; VAS: Visual Analogue scale; NDI: Neck Disability Index; CEET: Cervical Extensor Endurance Test.

Table 1.3: Results of Visual Analogue Scale, Neck Disability Index and Cervical Extensor Endurance Test before and after intervention in group 2- Deep Cervical Extensor Training

	Mean (SD)	SEM	95% CI of the difference		t	P
VAS			Lower	Upper		
Pre-intervention	5.24 (1.30)	0.24	1.68	2.80	8.157	0.000
Post-intervention	3.00 (1.60)	0.30				
NDI						
Pre-intervention	33.97 (8.34)	1.55	8.01	12.33	9.651	0.000
Post-intervention	23.79 (9.18)	1.70				
CEET						
Pre-intervention	14.90 (2.92)	0.54	-8.36	-5.84	-11.558	0.000
Post-intervention	22.00 (4.81)	0.89				

Note: SD: Standard Deviation; SEM: Standard Error of Mean; CI: Confidence Interval; VAS: Visual Analogue Scale; NDI: Neck Disability Index; CEET: Cervical Extensor Endurance Test.

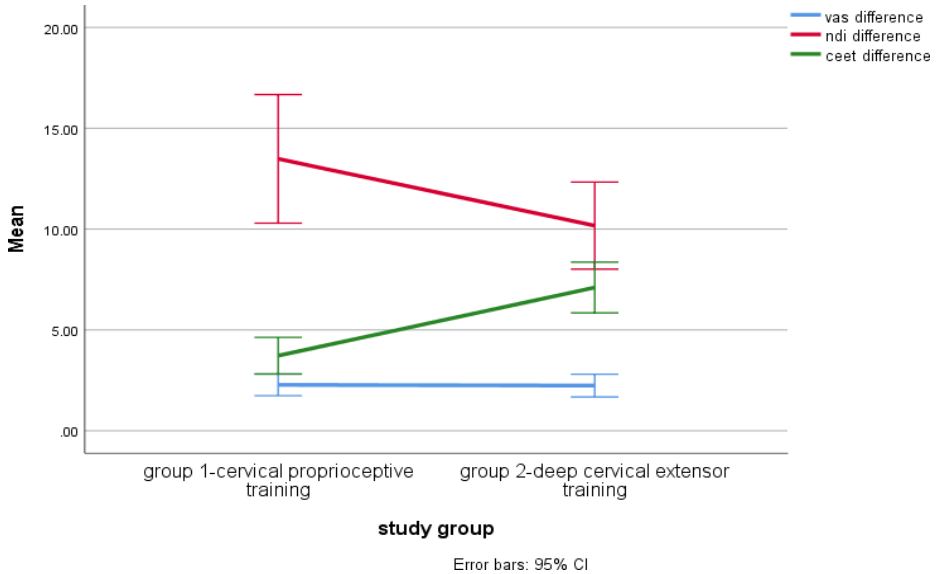

Fig 1.4 : Outcomes of Visual Analogue Scale, Neck Disability Index and Cervical Extensor Endurance Test difference between group 1-Cervical Proprioception Training and group 2-Deep Cervical Extensor Training

DISCUSSION

In this 6-week trial, the effects of a programme called Cervical Proprioception Training (CPT) versus Deep Cervical Extensor Training (DCET) on patients with Chronic Non-Specific Neck Pain (CNNP) were examined with respect to pain severity, functional status, and neck extensor muscle endurance.

The values obtained in the Visual Analogue Scale (VAS) during the CPT were statistically significant and demonstrated a significantly advantageous difference compared to the group that underwent the DCET. Previous study stated that the suboccipital muscles regulate the postural reflexes, which play a crucial role in coordinating the movements of the eyes and head. They also stated that a training period of 6 weeks has been found to result in noticeable improvements in cervical proprioception.[18] Better head-neck coordination may

result in more dependable proprioceptive afferents from the mechanoreceptor-rich cervical region, which is home to the visual and vestibular sensory organs. This could ultimately eliminate the requirement for the overactivity of the superficial cervical muscles, which is a significant cause of muscle soreness, by resulting in more exact and accurate motor signals to the cervical muscles .[20] Previous research revealed that integrating eye-head coordination with isometric movements of the deep neck muscles significantly reduced pain and disability in individuals suffering from neck pain.[22]

The CPT group showed a notable reduction in Neck Disability Index (NDI scores) in comparison to the DCET group (mean difference 13.48 vs 10.17). Additional research revealed similar findings, showing a significant decrease in NDI scores for both groups compared to pretreatment conditions. Furthermore, the study group demonstrated a noteworthy improvement in their VAS. The control group received conventional physical therapy, while the study group underwent proprioceptive training in addition to conventional physical therapy.[23]

DCET too indicated the presence of the treatment impact in lowering pain and improving functional status, which was one of our study outcomes. Prior discoveries aligned with our observations, indicating that a 6 week regimen targeting the semispinalis cervicis yields notable benefits in reducing pain severity, can effectively decrease functional disability and significantly improve neck-extensor muscle strength compared to the control group.[21] DCET group exhibited a greater improvement in neck extensor muscle endurance compared to the CPT group.The mean difference between the two groups was 3.38, which was the highest among the three outcome measures.The results showed that the DCET group demonstrated more significant training effects.However, it is important to acknowledge the impact of CPT on CEET scores as well. This is due to the mean CEET scores of the participants in the CPT group being significantly different at baseline and sixth-week. This suggests that CPT demonstrated advantages in enhancing the motor control of cervical extensor muscles.Parallel findings were reported in which they explored the effects of cranio-cervical flexion training versus proprioception training on the cranio-cervical flexion test outcomes, a measure of the deep cervical flexors' neuromuscular control. Their research concluded that either training modality equally benefited test performance, suggesting that proprioception exercises could bolster deep cervical flexor functionality.[19] A systematic review indicated that proprioceptive training has the potential to result in substantial enhancements in both proprioceptive and motor function among various healthy and clinical groups. Experimental data suggests that therapies targeting the enhancement of somatosensory function not only enhance proprioception but also motor function.[24]

Chronic pain has the ability to modify the sensitivity of the muscle spindle receptors and disrupt the incoming proprioceptive signals. Diminished proprioception has been linked to reduced engagement in the deep muscle group, which encompasses the proprioceptive network.[6]These findings underscore the mutual influence of proprioception and muscle endurance. Better head-neck coordination eliminates the requirement for the overactivity of the superficial cervical muscles, which is a significant cause of muscle soreness, by resulting in more exact and accurate motor signals to the cervical muscles .[20] The dense population of muscle spindles in the deep cervical muscles could explain why proprioception training impacts the activation and control of these muscles .These variables may also account for the improvement in cervical extensor muscular endurance (CEET scores) following CPT.

CONCLUSION

The findings of the present study suggested that both Cervical Proprioception Training and Deep Cervical Extensor Training groups after a 6-week protocol showed improvement in pain intensity, neck extensor muscle endurance and functional status. This suggests that training focused on proprioceptive awareness could also benefit the strengthening of the deep cervical extensor muscles. Consequently, exercise training should prioritize modifying particular muscle dysfunction, particularly the deep cervical extensor muscles as determined by evaluation. Therefore, it is essential to treat the limitations of the neck musculature using an endurance test as part of problem-based care for patients with CNP. There is no single test that can definitively or comprehensively assess cervical muscle function. However, a simple endurance test, such as the cervical extensor endurance test, can be readily performed in a typical clinical setting due to its minimal time requirements, enhanced efficiency, and increased effectiveness.

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