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Effects of Cervical Proprioceptive Training Using Head-Mounted Laser in Patients with Chronic Mechanical Neck Pain

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KEYWORDS

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DECLARATIONS

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ABSTRACT

Background: Chronic mechanical neck pain is a widespread musculoskeletal issue that often results in pain, reduced mobility, and functional limitations. It is commonly associated with poor posture and deficits in proprioception. Proprioceptive training aims to restore joint position sense and improve neuromuscular control. Tools like head-mounted lasers provide visual feedback to enhance training. **Objective:** To determine the effects of proprioceptive training of the cervical spine on pain, range of motion, joint position sense, and disability in chronic mechanical neck pain. **Methodology:** This randomized controlled trial was conducted on chronic mechanical neck pain subjects, both genders, with an age between 45 and 55 years, at Shahida Khaliq Health Centre, Islamabad. This trial is registered at www.clinicaltrials.gov NCT06034223 on September 11, 2023. A total of 36 participants were included in this study, and data were collected on a structured questionnaire. The patients were randomly assigned to either the treatment or control group, each with 18 individuals, using the lottery method. Both groups underwent conventional physical therapy treatment, with the treatment group receiving additional proprioceptive training using a head-mounted laser. The treatment protocol spanned four weeks, three days per week. Data collection involved a self-structured questionnaire encompassing range of motion, numeric pain rating scale, neck disability index and cervical joint position sense error. Cervical range of motion was evaluated using a bubble inclinometer. The Shapiro-Wilk test was applied to check the normality of the data. Paired sample T-test was applied for within-group comparison of variables, and an independent T-test for between-group comparison of variables. **Results:** The Mean age of the participants was 49.4±3.29, 07 (7.1%) of them were men, and 29 (92.9%) were women. The treatment group demonstrated significantly greater improvements ($p<0.05$) in cervical flexion, left and right lateral flexion range of motion, joint position error, pain intensity, and neck disability index. **Conclusion:** It is concluded that a four-week proprioceptive training intervention effectively enhances cervical flexion and lateral flexion range of motion on both sides, while concurrently reducing joint position error, pain intensity, and neck-related disability.

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INTRODUCTION

Mechanical neck pain (MNP) is a result of the neck being strained, which can happen from prolonged posture or certain actions. Mechanical neck pain can have several causes, including but not limited to degenerative changes, inflammation, trauma, poor posture, and movements involving the cervical spine. It can also be caused by structural and functional impairments of the cervical muscles. With an annual frequency of 48.5%, it is the third leading cause of disability globally, affecting quality of life. About 30% to 50% of middle-aged people suffer from mechanical neck pain, which is a common dysfunction. Mechanical neck pain may be more common in jobs, such as computer work, that demand repetitive neck movement or require maintaining a specific posture for extended periods of time.[1,2] Several anatomical and functional characteristics help to identify mechanical neck pain.[3] According to estimates, up to two-thirds of individuals may experience neck discomfort at some time in their lives, and 10% to 20% of people will experience it annually. It carries a substantial individual impact, contributing to disability-adjusted life-years.[4]

One of the main challenges that people with neck pain often face is an impairment in cervical proprioception. Other problems include limited mobility and range of motion (ROM), heightened vulnerability to muscular fatigue, and diminished strength and endurance.[3] Numerous exercises, massage, acupuncture, and conventional medical care are among the conservative methods used to manage mechanical neck pain.[5] The proprioceptive system in the cervical spine is extremely sensitive and indicates where the head is in relation to the body.[6] It also coordinates the vestibular and visual systems, controls posture and balance, and is vital for spatial orientation. Age, discomfort, muscular exhaustion, forward head position, cervical spondylosis, and other factors have been linked to deficiencies in proprioception of the cervical spine, aberrant posture, and the cervical spine's altered motor control and diminished neck muscular strength, which affects balance control and coordination.[2]

Randomized controlled studies have shown evidence that proprioceptive-targeted therapy reduces pain and enhances JPS at the neck.[7] Research so far indicates that the basic causes and downstream consequences of changes in proprioceptive activity may need to be addressed in the therapy of sensorimotor control problems brought on by chronic neck pain. There are numerous approaches to treating cervical proprioception. This includes deep cervical flexor and extensor muscle retraining, proprioception training, strengthening exercises, cervical manipulation, acupuncture, and several more conventional treatments.[8]

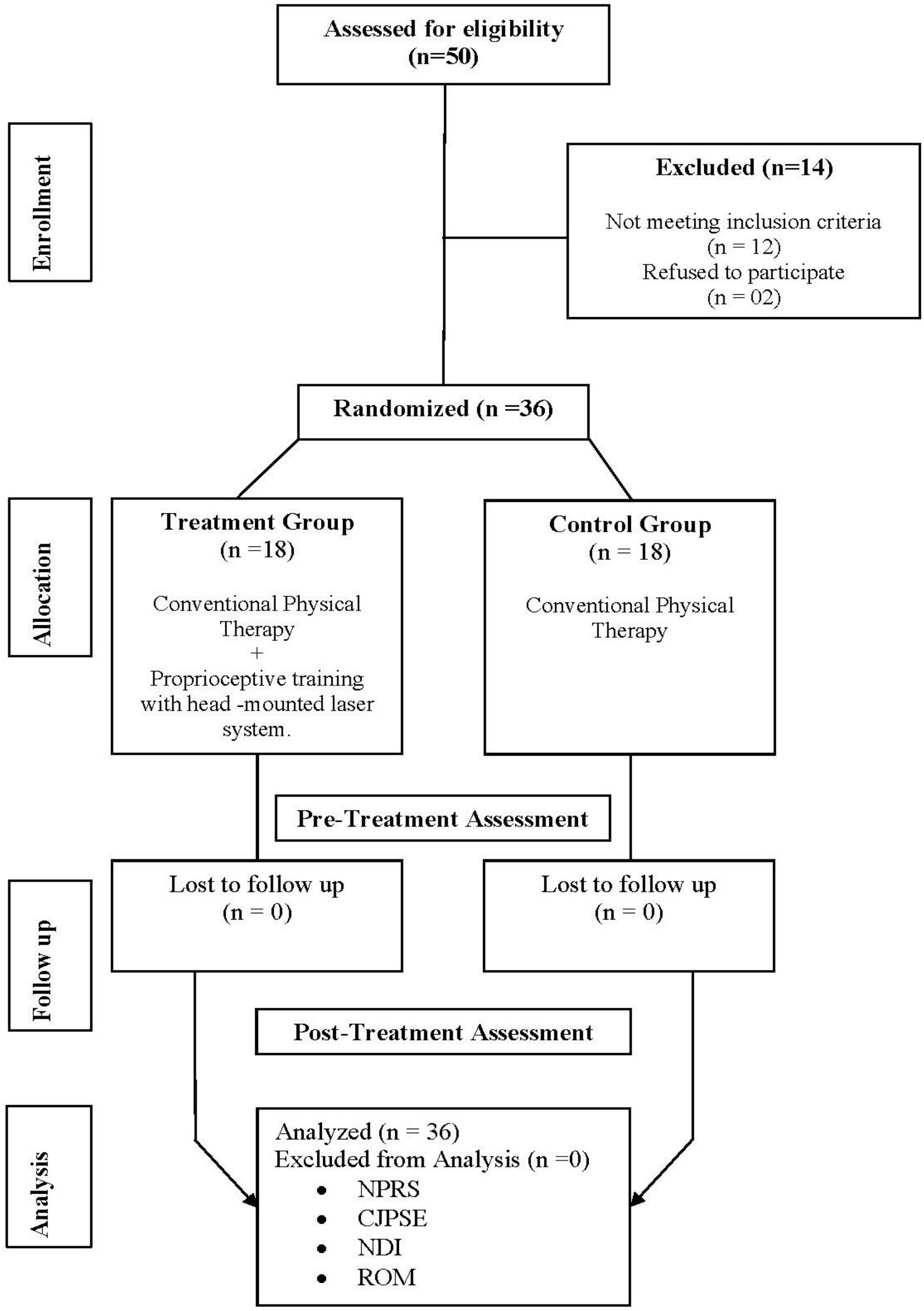
This study aimed to investigate the advantages of head-mounted laser cervical proprioception training compared to conventional physical therapy concerning cervical proprioception, cervical range of motion, discomfort, irritation, and disability in individuals suffering from pain in the neck for more than three months, which is mechanical in nature. In this study, cervical proprioception, pain, range of motion, and disability in patients with chronic mechanical neck pain will be compared to the effects of traditional physical therapy with and without cervical proprioception training utilizing a head-mounted laser. Mechanical neck discomfort also disrupts proprioception. This study intended to deliver optimal exercise therapy services at an affordable cost and with minimal waiting time.

There is a literature gap on the efficacy of proprioceptive training paired with conventional physical therapy, with or without a head-mounted laser system. A few studies have directly contrasted the outcomes of standard physical therapy with and without proprioceptive training, as well as solely the effects of standard physical therapy treatment. This study can also serve to build the basis for additional investigations while developing treatment regimens for the stated population, because this issue has not previously been investigated in Pakistan.

METHODOLOGY

This randomized controlled trial was conducted on chronic MNP subjects, both genders, with ages ranging from 45 to 55 years, at Shahida Khaliq Health Centre (Islamabad). This trial is registered at www.clinicaltrials.gov NCT06034223 on September 11, 2023. A total of 36 participants were included in this study, and data were collected on a structured questionnaire. The patients were randomly assigned to either the treatment or control group, each with 18 individuals, using the lottery method. Both groups underwent conventional physical therapy treatment, with the treatment group receiving

Figure 1: CONSORT diagram



additional proprioceptive training using a head-mounted laser. The treatment protocol spanned four weeks, three days per week. Measurements were taken before and after the treatment protocol.

Data collection involved a self-structured questionnaire encompassing ROM, Numeric Pain Rating Scale (NPRS), Neck Disability Index (NDI), and Cervical Joint Position Sense Error (CJPSE). NPRS scale was used to record the intensity of pain with high reliability (0.95 to 0.96) and (0.86 to 0.96) validity.[13] Cervical ROM was evaluated using a Bubble inclinometer. To measure, we placed the inclinometer device on the person's head, aligning it along the sagittal and coronal planes and on the forehead just above the eyebrows while the person was in a neutral spine position for forward, backwards, side-bending, and rotation measurements, respectively. The NDI was evaluated and documented within the questionnaire. The CJPSE was evaluated using a modified headgear equipped with an integrated laser; the laser tracker has an interclass correlation coefficient (ICC) value of 68%. After the initial assessment, a 30-minute session of conventional

Table 1: Wilcoxon signed-rank test for within-group comparison of variables

Variables	Groups	Pre-treatment Mean±SD	Post-treatment Mean±SD	p-value
NDI	Control	6.5±1.1	1.3±0.97	0.39
	Experimental	6.1±1.5	2.7±1.59	0.00
Cervical flexion	Control	50.7 ± 6.49	65.2±9.36	0.25
	Experimental	48.0±7.66	53.7±7.69	0.00
Cervical extension	Control	41.7±9.54	55.3±6.32	0.50
	Experimental	43.8±9.28	50.8±10.2	0.12
Cervical right rotation	Control	40.0±7.64	53.2±8.71	0.35
	Experimental	42.3±7.63	50.5±6.93	0.30
Cervical left rotation	Control	26.5±4.31	54.7±6.93	0.28
	Experimental	25.0±3.4	50.2±9.2	0.11
Cervical flexion ROM error	Control	9.13±2.43	3.52±1.65	0.00
	Experimental	10.40±2.17	5.95±1.72	0.00
Cervical extension ROM error	Control	8.20±9.95	3.31±1.33	0.00
	Experimental	9.95±2.69	6.33±2.20	0.00
Cervical right side bending ROM error	Control	9.37±2.74	3.03±1.27	0.00
	Experimental	9.48±1.86	6.33±1.53	0.00
Cervical right rotation ROM error	Control	9.02±2.89	3.28±2.02	0.00
	Experimental	9.24±2.41	5.73±1.92	0.00
Cervical left rotation ROM error	Control	8.96±2.53	3.31±1.05	0.00
	Experimental	9.20±2.64	6.54±2.16	0.00

physical therapy was administered to the control group. This included both manual and electrotherapy. Manual exercises include cervical range of motion, i.e., flexion, extension, lateral rotation, and rotation (15 repetitions x 3 sets). Neck isometric exercises, i.e., flexion and extension isometrics, lateral neck isometrics, and neck rotation isometrics (3 sets of 15 repetitions with 15-second hold). Stretches targeting the scalene, trapezius, and sternocleidomastoid (SCM) muscles (1 set of 5 repetitions with 45-second hold). In addition, incorporate a ten-minute session of Transcutaneous Electrical nerve stimulation (TENS) while using a heating pad on the cervical region.[9] The patient received therapy for four weeks, three days a week. The treatment group received conventional physical therapy along with proprioceptive exercises utilizing a head-mounted laser.

Exercises included tracing the figure of 8 with eyes open, i.e., 15 repetitions x 3 sets. Patients were asked to maintain an upright seated position with the head laser pointer positioned at the top of the head. After aligning the laser with the patient sitting 90 cm away from the wall, ensuring it pointed straight ahead as the patient gazed directly forward. The figure of an 8-shaped poster was pasted onto the wall, and the patients were told to move the laser inside the track. This was carried out with the eyes open, using input from a laser mounted to the head, essentially tracing the figure.[8,9] Data was analyzed using SPSS version 26, and the Shapiro-Wilk test was applied to check the normality of the data. Paired sample T-test was applied for within-group comparison of variables, and an independent T-test for between-group comparison. The p-value <0.005 is considered significant.

Table 2: Paired sample T-test for within-group comparison of variables

Variables	Groups	Pre-treatment Mean Rank	Post-treatment Mean Rank	p-value
NPRS	Control	19.81	23.17	0.000
	Experimental	17.19	13.83	0.007
Cervical right side bending	Control	17.06	12.53	0.394
	Experimental	19.94	24.47	0.001
Cervical left side bending	Control	19.81	11.17	0.444
	Experimental	19.81	25.83	0.000
Cervical left side bending ROM error	Control	18.44	25.78	0.000
	Experimental	18.44	11.22	0.000

RESULTS

A total of 36 patients, with a mean age of 49.4±3.29, freely participated in the study; of them, 07 (7.1%) were men and 29 (92.9%) were women. According to the obtained findings of each variable, pre- and posttest information related to NPRS, right and left SB, and left joint position errors in cm (JPE) of the patients were analyzed using the Wilcoxon analysis (Table 1). Paired sample T-test was used for NDI, CROM and JPE except left JPE. On the other hand, for the between-group analysis, an independent t-test was applied on NDI, CROM, and JPE, except for the left JPE. The Mann-Whitney T test was used for NPRS, Right and left side bending (SB), and left joint position errors in cm (JPE), as shown in Table 2. Results indicated cervical flexion, left and right-side bending range of motion, while simultaneously reducing joint position error, pain, and neck disability index showed significant improvement in the experimental group, $p<0.05$.

DISCUSSION

The results of the present study indicated the benefits of proprioceptive exercises for improving neck pain, range of motion, and disability. These findings are supported by the findings of M Durray et al (2018), who claimed that Physiotherapy programs should incorporate proprioceptive training to enhance balance and reduce the degree of impairment.10 Our results were comparable to the findings of Rezaei I et al., who found that pain on VAS scoring was greatly decreased after five weeks of proprioceptive training, while the experimental group exhibited a significant drop in pain level after 4 weeks of exercises.[11]

Another RCT conducted in 2018 concluded that pain was significantly improved by deep proprioceptive training of flexors of the neck as compared to traditional physical therapy interventions; these results were consistent with our study.[7] A study conducted by Tomás Gallego et al indicated that conventional physical therapy and proprioceptive training both have a comparable effect on neck pain and mobility.[12] An improvement in neck disability index using NDI was observed in our study, which showed that proprioceptive exercises can be beneficial in improving disability level at the cervical level, which was supported by an RCT conducted in 2018, showing that Physiotherapy programs should incorporate proprioceptive training to enhance balance and reduce the degree of impairment.[10]

However, research on the effects of exercise on motor function produces rather conflicting results. One potential explanation for this contradiction is the diverse group of patients participating in the trials. It is suggested that the fundamental cause of this variability is that patients with chronic neck pain may not be aware that they require therapy since their dizziness does not coincide with other symptoms, and they are unable to identify their balance problems. Proprioceptive exercise was shown to be beneficial in lowering pain and impairment in female dentists who experienced recurrent neck discomfort, in an RCT conducted by Anahita Bolandian et al. These results positively reinforced our findings.[13]

Table 3: Independent T-test for between-group comparison of variables

Variables		Control Mean±SD	Experimental Mean±SD	p-value
NDI	Pre-treatment	35.61±4.66	40.61±3.86	0.000
	Post-treatment	28.61±5.46	25.16±4.11	0.000
Cervical flexion	Pre-treatment	48.05±7.66	50.77±6.49	0.000
	Post-treatment	53.72±7.69	65.27±9.36	0.000
Cervical extension	Pre-treatment	43.88±9.28	41.77±9.54	0.000
	Post - treatment	50.88±10.23	55.33±6.32	0.000
Cervical right rotation	Pre-treatment	42.38±7.63	40.00±7.64	0.000
	Post-treatment	50.50±10.23	53.22±8.71	0.000
Cervical left rotation	Pre-treatment	44.33±10.10	40.88±8.90	0.000
	Post-treatment	50.27±9.27	54.77±7.36	0.000
Cervical flexion ROM error	Pre-treatment	10.40±2.17	9.13±2.43	0.000
	Post-treatment	5.95±1.72	3.52±1.65	0.000
Cervical extension ROM error	Pre-treatment	9.95±2.69	8.20±2.07	0.000
	Post-treatment	6.33±2.20	3.31±1.33	0.000
Cervical right side bending ROM error	Pre-treatment	9.48±1.86	9.37±2.74	0.000
	Post-treatment	6.33±1.53	3.03±1.27	0.000
Cervical right rotation ROM error	Pre-treatment	9.24±2.41	9.02±2.89	0.000
	Post-treatment	5.73±1.92	3.28±2.02	0.000
Cervical left rotation ROM error	Pre-treatment	9.20±2.64	8.96±2.53	0.000
	Post-treatment	6.54±2.16	3.31±1.05	0.009

A study on the impact of a proprioceptive exercise program on position sense, pain, and disability in patients with cervical spondylosis who have chronic neck pain found that after 24 treatment sessions, there was better proprioception, less pain intensity, and less disability compared to the conventional physical therapy group.[14] Joint position sense error was also noticed in our study in both groups before and after intervention. It showed great improvement in the experimental group in all ranges, including flexion, extension, rotation, and side bending. A systematic review by Hiroshi Takasaki et al in 2018 summarized that joint position sense was significantly improved by proprioceptive training, consistent with our results.[15] In future studies, it is recommended to collect data from different geographic regions to increase the generalizability of the findings. It is recommended to target patients with other conditions, such as spondylosis and forward head posture, to the effects of proprioceptive training in these conditions.

CONCLUSION

It is concluded that a four-week proprioceptive

Table 4: Mann-Whitney U-test for between-group comparison of variables

Variables		Control Mean Rank	Experimental Mean Rank	p-value
NPRS	Pre-treatment	19.81	17.19	0.000
	Post-treatment	23.17	13.83	0.007
Right side bending	Pre-treatment	17.06	17.06	0.000
	Post-treatment	12.53	24.47	0.010
Left side bending	Pre-treatment	19.81	19.81	0.000
	Post-treatment	11.17	25.83	0.000
Left Cervical Left side bending ROM error	Pre-treatment	18.44	18.44	0.000
	Post-treatment	25.78	11.22	0.000

proprioceptive training intervention helps increase cervical left flexion, and right-side bending range of motion, while simultaneously reducing joint position error, pain, and neck disability index. Decreased pain can be achieved by using both approaches (conventional physical therapy and proprioceptive training), but the goal is to rectify joint position errors, range of motion, and disabilities. There was a significant difference found between the groups.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of Data and Materials: Data will be made available upon request. The corresponding author will submit all dataset files.

Competing interests: None

Funding: No funding source involved.

Authors' contributions: All authors had read and approved the final manuscript.

CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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