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# EFFECTS OF HIGH POWER LASER PLUS MANUAL THERAPY VERSUS MANUAL THERAPY ALONE ON MUSCLE ACTIVITY IN PATIENTS WITH CHRONIC CERVICAL RADICULOPATHY

**Hassan Namvar[1], Siamak Bashardoust Tajali[2*], Gholamreza Olyaie[2], Hossien Bagheri[2], Sharareh Saneie Sistani[3], Mohammad Hosienifar[4]**

[1]PhD Student, Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.
[2*]PT PhD, Deputy Dean of International Affairs-Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran. (https://orcid.org/0000-0001-5415-5196)
[3]PT, PhD, Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.

***Corresponding Author:** Siamak Bashardoust Tajali
PT PhD, Deputy Dean of International Affairs-Department of Physical Therapy, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran. (https://orcid.org/0000-0001-5415-5196) Tel & Fax: +9821, E-mail: s_bashardoust@sina.tums.ac.ir

**Abstract**

**Background**: Muscles activity changes may occur in chronic neck pain, but there are few RCTs on specific changes in muscle activity chronic neck pain and also after using High Power Laser. The aim of this research was to study effects of High Power (H.P.) Laser plus Manual Therapy Versus Manual Therapy alone on Muscle Activity in Chronic Cervical Radiculopathy Patients.

**Materials and Methods**: Frothy two patients with Chronic Cervical Radiculopathy were recruited for this double blind randomized clinical trial. The patients were randomly divided into Manual therapy plus H.P. Laser group and Manual therapy alone group. The Manual therapy plus H.P. Laser group was treated with High-Power Laser model K-LASER in addition to manual therapy. The Manual therapy alone group received suboccipital muscle release method, ULTT for median and radial nerve, chin tuck exercise, and resistance and stretching exercises. The interventions were conducted three times per week for 6 weeks. The activity of Flexor Carpi Radialis muscle (RMS) was evaluated before and after third and sixth weeks of the interventions by electromyography (EMG) instrument. The evaluations were also repeated two months after treatment accomplishment as follow up of the treatment effectiveness. The pain was assessed using Visual Analog Scale and the disability was assessed using Neck Disability Index questionnaire. Data were analyzed with multiple ANOVA Repeated measure and Bonferroni tests ($p<0.05$).

**Results**: In Manual therapy plus H.P. Laser group, pain and disability index significantly decreased in all of assessment ($p<0.05$). There was also significant improvement in pain and disability index between two groups ($p<0.05$). The mean of RMS Flexor Carpi Radialis muscle was statistically significant in both groups ($p>0.05$).

**Conclusion:** The current study showed that High Power Laser can significantly reduce pain and improve function and muscle activity in patients with Chronic Cervical Radiculopathy. So, High-Power Laser can be considered as an effective and non-invasive method for the treatment of patients with Chronic Cervical Radiculopathy.

**Keywords: High-Power Laser, Muscle Activity, Flexor Carpi Radialis.**

## Introduction

Cervical radiculopathy is caused by pressure and inflammation of cervical nerve roots and causes sensory and motor dysfunctions in neck and upper limb (1,2). Muscle function is also affected due to cervical radiculopathy (3). The results of electromyography studies suggest that following cervical pain, the activity level of deep postural muscles decreases, the onset of postural muscle activity delays, cervical muscle fatigue increases, and co-contraction is observed in cervical muscles (3-9). The activity balance between superficial and deep muscles is disturbed and activity level of the cervical deep flexor and extensor muscles, including the longus colli and longus capitis, and the multifidus muscles decreases. Also, the activity of the superficial muscles, including the sternocleidomastoid and anterior scalene muscles are increased (10,11). As a result, the goals of treatment in these patients are to reduce pain, improve muscle balance activity and correct the movement pattern (12). Physiotherapy techniques and modalities were usually used in cervical radiculopathy patients include pain relief modalities, exercise therapy, cervical spine traction, manual therapy, and posture correction training (2,13,14,15).

Laser therapy is one of the alternative and complementary modalities used in a wide range of musculoskeletal disorders, including low back pain, non-specific neck pain, osteoarthritis, knee pain, and temporomandibular joint disorders (15-20). Laser therapy is a non-invasive and useful modality that apply nowadays as an extensively-used modality in physiotherapy clinics. Studies suggest that laser can be used as an effective modality to reduce pain and improve function in musculoskeletal disorders (21-25). A study by Shady et al. (2021) revealed the effectiveness of High-Intensity Laser in reducing pain and disability and improving grip strength and cervical range of motion in patients with cervical radiculopathy (21). Roy et al. (2018) compared two types of treatment, low laser therapy, and cervical traction on patients with cervical radiculopathy. The results showed that the mean intensity of pain and disability in high-power laser group was lower than cervical traction group (22). Haladaj et al. (2017) also indicated similar results at the patients with cervical radiculopathy (23). Abdullah et al. (2017) compared two types of low-intensity laser and Mulligan's SNAG technique in people with unilateral cervical radiculopathy. The comparison of these two groups did not show any statistically significant differences (24).

According to the results of the systematic review studies, there is no definite evidence about the effectiveness of different physiotherapy treatments in cervical pain caused by radiculopathy, and none of the treatment methods has significant priority over the others. In addition, there are no adequate and high quality studies with identical methodology in this field can be reached. Therefore, it is difficult to make conclusion about the effectiveness of laser in patients with cervical radiculopathy. Thus, the present clinical trial study investigated effects of Manual therapy plus H.P. Laser versus Manual therapy alone on wrist flexor muscle activity in patients with chronic cervical radiculopathy.

## Methods

This study was a double blind randomized controlled trial. Forty-two subjects with chronic radicular neck pain participate in this study and were randomly divided into two groups by simple non-probability sampling method. The medical ethics committee at the Tehran University of Medical Sciences approved the study ethics (ethics certification number: IR.TUMS.FNM.1401.050) and the

study was registered with the region's Clinical Trials Registry (IRCT2022062655278N2) as well. All participants signed written informed consents.

**Inclusion Criteria**

Inclusion criteria included men and women aged between 20 and 55 years, with radicular neck pain due to discopathy in C5-6 roots, pain and paresthesia in arm and hand (lateral elbow, thumb, index, or middle finger), and lack of muscle atrophy, Current neck pain (sense of pain anywhere in posterior of cervical spine, from superior nuchal line to the first thoracic spinous process) of at least 3 months' duration in the past year, no history of fracture, no structural abnormalities, no history of dizziness and head trauma. Also, the eligible patients must have no history of progressive rheumatic and neurological diseases, no history of long-term use of corticosteroids, no history of accident and whiplash injury, malignancy or pregnancy (22,25,26).

**Exclusion Criteria**

Exclusion criteria included pain or inflammation in neck, receiving other treatment during six weeks of the research, unwillingness to continue treatment, not completing the treatment sessions, taking painkillers, sedatives and alcohol at least 48 hours before the test.

**Sample Size**

The sample size was determined based on a pilot study. Ten subjects were divided randomly into two equal groups, and the main part of the study was conducted for the pilot patients. The means and SDs of this pilot study, with $\alpha = 0.05$ and 90% power were used to calculate the sample size.

$$n = (Z_{1-\alpha/2} + Z_{1-\beta})^2 (S_1^2+S_2^2)/ (\mu_1-\mu_2)^2$$

$$Z_{1-\alpha/2} = 1.96$$

$$Z_{1-\beta} = 1.28$$

According to the results of the pilot and the formula stated, the sample size in each group was considered 22 patients.

The sampling method was the simple, non-probabilistic sampling method and from the available population. The participants will then be allocated randomly into two intervention groups, the manual therapy with laser and manual therapy alone groups. Randomization will be performed using random number sequence. The administrator and participants were informed about the grouping data. But the physiotherapist who assessed the patients, measured the outcomes, and analyzed the data were blinded about the grouping.

**Procedure**

The initial clinical examination was performed by demographic information, MRI report, patient history and clinical tests including Spurling test (27,28) and Upper Limb Tension Test (ULTT) or Elvey's test (27) for diagnosing radicular pain. Then, the individuals were selected to enter the study by examining the inclusion and exclusion criteria.

**Primary Outcomes**

Pain intensity: The VAS (Visual Analogue Scale) of McGill Short Questionnaire was used to measure the intensity of pain (29). The VAS is a 10-cm, non-graded horizontal line with fixed boundaries from no pain to worst possible pain, on which the patient marks his/her pain severity.

Disability index: Neck Disability Index questionnaire was used to obtain neck disability level of patients. The score zero in this questionnaire indicates a lack of problem and as this score goes up, it indicates an increase in disability level (30).

**Secondary Outcomes**

Flexor Cari Radialis Muscle Activity: In the present study, a surface electromyography device (Bio Graph Infiniti, 2180 Belgrave Avenue, Montreal, QC H4A 2L8 Canada) was used to record the electrical activity of the Flexor Cari Radialis Muscle (31).

The patient seated on chair. The forearm area was completely exposed and completely shaved and then cleaned of fat with alcohol. Electrodes were placed on muscle motor unit (31). After selecting the EMG 10 channel, the required chart type was selected from the RMS option. Ambient noise was reduced using a band pass-filter that filters frequencies below 10 Hz and above 500 Hz. A conductive gel was used before attaching the electrodes.

To record maximum electrical activity of the Flexor Cari Radialis Muscle, the patient placed elbow in extension and flexed the wrist joint by maximum resistance. To record the functional activity of flexor carpi radialis, the patient was performed flexion and radial division in wrist. This level of contraction was maintained and recorded for 5 seconds. This task was repeated 3 times and the patient was allowed to have a 2-minutes break between two tasks to avoid fatigue.

Muscle activity was normalized using the following formula:
Muscle activity level = RMS/MVC × 100

**Interventions**

The patients were randomly divided into two groups: Manual therapy plus H.P. Laser group and manual therapy alone group. The patients in both groups received routine physiotherapy treatment including TENS (burst, 20min) and hot pack (20min).

In the Manual therapy group (15,33), suboccipital muscle release by Greenman method, ULTT for median and radial nerve by Butler methods, chin tuck exercise, and resistance and stretching exercises for Trapezius, Sternoclidomastoid, Scaleni and Rhomboid muscles were performed. The exercises were completed in three sets with 10 repetitions under the supervision.

In manual therapy with laser group, a High-Power Laser instrument with a wavelength of 660, 800, 905, 970 nm (K-LASER, made Italy) was used with the probe held at 90° angle and noncontact and pulse and continuous mode. The High-Power Laser parameters were as follows:
Phase-1: peak power: 9.6w, t:28s, average power: 9.6, applied joule: 226, continue mode.
Phase-2: peak power: 20w, t:28s, average power: 9.6, applied joule: 270, frequency: 2hz.
Phase-3: peak power: 20w, t:28s, average power: 9.6, applied joule: 269, frequency: 10hz.
Phase-4: peak power: 20w, t:28s, average power: 9.6, applied joule: 269, frequency: 50hz.
Phase-5: peak power: 20w, t:28s, average power: 9.6, applied joule: 268, frequency: 100hz.
Phase-6: peak power: 20w, t:28s, average power: 9.6, applied joule: 270, frequency: 500hz.
Phase-7: peak power: 20w, t:28s, average power: 9.6, applied joule: 268, frequency: 2500hz.
Phase-8: peak power: 20w, t:28s, average power: 9.6, applied joule: 270, frequency: 7500hz.
Phase-9: peak power: 20w, t:28s, average power: 9.6, applied joule: 269, frequency: 15000hz.
Phase-10: peak power: 20w, t:28s, average power: 9.6, applied joule: 270, frequency: 20000hz.
Phase-11: peak power: 9.6w, t:28s, average power: 9.6, applied joule: 268, continue mode.

Thus, the total application time was 5:08 minutes and the total energy applied was 2957 J. The participants and the examiner used opaque goggles for protection (Figure 2).
The patients were treated in 18 sessions three days a week for six weeks (15, 33). All the variables were measured before intervention, at third and sixth weeks and two-months after treatment accomplishment.

**Data analysis**

The results were presented as mean values and standard deviations (SD). Criterion of significancy was set as $p<0.05$. Data analysis was performed with SPSS version 27. The assumption of a normal distribution was assessed using the Shapiro-Wilk test. The assumption of equality of variances was analyzed using Levene's test. The Mixed model repeated measure ANOVA and Bonferroni correction were used for within- and between-group comparisons.

**Results**

Fifty-six people were nominated for this study and 48 of these patients were divided into two groups: Manual therapy plus H.P. Laser and Manual therapy alone (Fig-1). Figure 2 presents the recruitment strategy and experimental plan. The pilot study showed that 22 subjects would be needed for each group (a total of 44 subjects). Ultimately, 42 subjects finished the study procedure. Eight of them were not eligible based upon the inclusion and exclusion criteria. Four subjects from the Manual therapy alone exercise group and two subjects from Manual therapy and H.P. Laser group left the study because of personal problems, unwillingness to continue treatment and incomplete treatment or reasons unrelated to the investigation. The flowchart of choosing participants in the study is shown in Figure 1.

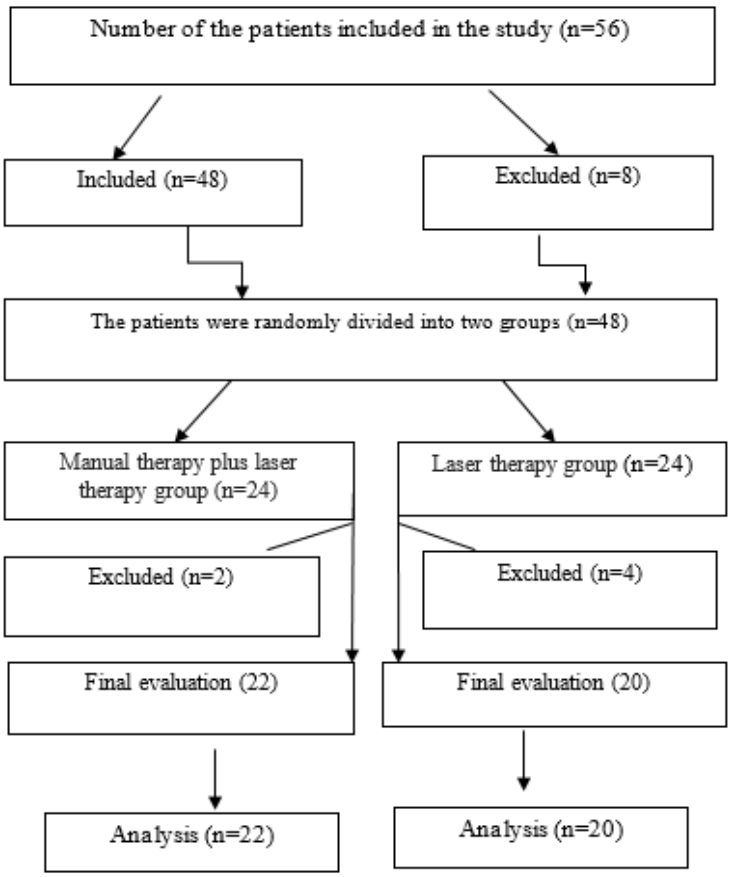


**Fig-1**: Flow diagram of study selection.

Data were analyzed by the SPSS 27 software. The normality of data distribution was examined by the Shapiro-Wilk test. The p-value was not less than 0.05 in the variables of the study. Thus, the tests did not reject the hypothesis of normality and the data were normal ($p>0.05$). Table-1 presents the demographic characteristics of patients including age, height, weight, and body mass index. The demographic characteristics of the patients, which were recorded before intervention, were compared between the two groups. There were no significant differences between two groups of study (Table-1).

**Table-1**- Comparison of demographic characteristics between two groups.

| Demographic Data | MHPLG* | MTG* | sig** |
|---|---|---|---|
| Age (years) | 47.05±8.6 | 44.50±8.5 | 0.34 |
| Weight (kg) | 77.27±13.1 | 74.05±11.2 | 0.40 |
| Height (cm) | 169.64±6.2 | 167.50±5.9 | 0.26 |
| Body Mass Index (BMI) ($m^2$/kg) | 26.66±3.0 | 26.25±2.7 | 0.64 |
| Visual Analogue Scale (VAS) | 7.36±1.0 | 7.35±0.9 | 0.96 |
| Disability Score (NDI) | 30.00±5.3 | 28.5±4.6 | 0.34 |

* mean ± standard deviation. ** A significance level of less than 0.05. MHPLG: Manual therapy plus H.P. Laser group. MTG: Manual therapy alone group.

To examine the homogeneous of the volunteers in two groups before intervention, a t-test was used. The results showed that the data in two groups were equal and homogeneous (p>0.05).

**Within group and between group comparison**

**Table 2**- within and between groups comparison of the muscle activity of the flexor carpi radialis.

| | MHPLG* | | | | | MTG* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before intervention | Third week | Sixth week | 2 months later | Sig ** | Before intervention | Third week | Sixth week | 2 months later | Sig** | Between group Sig.** |
| RMS | 41.59±13.0 | 58.47±19.8 | 75.32±28.6 | 51.33±13.6 | 0.000 | 40.45±15.0 | 50.38±14.7 | 61.54±17.8 | 51.87±14.6 | 0.000 | 0.24 |

*mean ± standard deviation. ** A significance level of less than 0.05. MHPLG: Manual therapy plus H.P. Laser group. MTG: Manual therapy alone group. RMS: Root Mean Square.

The results of Table 2 showed that the muscle activity of the flexor carpi radialis had significant changes in both groups (p<0.05). However, there was no significant differences between the groups (p>0.05).

**Table 3**- Bonferroni test for the muscle activity of the flexor carpi radialis.

| | | | Sig. MHPLG* | Sig. MTG * |
|---|---|---|---|---|
| RMS | Before intervention | Third week | 0.002 | 0.002 |
| | | Sixth week | 0.000 | 0.000 |
| | | 2 months later | 0.000 | 0.001 |
| | Third week | Sixth week | 0.001 | 0.000 |
| | | 2 months later | 0.52 | 1.000 |
| | Sixth week | 2 months later | 0.004 | 0.004 |

* A significance level less than 0.05. MHPLG: Manual therapy plus H.P.Laser group. MTG: Manual therapy alone group. RMS: Root Mean Square.

The results of Bonferroni test showed a significant difference in the RMS in both groups at all times (p<0.05). (Table 3)

**Table 4**- Between group comparison and ANOVA test.

| . | . | Sig * |
|---|---|---|
| Muscle Activity | Before intervention | 0.80 |
| | Third week | 0.14 |
| | Sixth week | 0.06 |
| | two months later | 0.80 |

* A significance level less than 0.05.

The results of the between group comparison showed that there was no significant difference between two groups (p>0.05).

**Table-5.** Within and between groups comparison of pain and disability outcome measures.

| | MHPLG * | | | | | MTG * | | | | | Between group sig. ** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before intervention | Third week | Sixth week | Two months later | sig** | Before intervention | Third week | Sixth week | Two months later | sig** | |
| Pain | 7.36±1.0 | 2.95±0.6 | 2.27±0.6 | 2.32±0.8 | 0.000 | 7.35±0.9 | 4.25±0.9 | 3.50±1.0 | 3.65±1.0 | 0.000 | 0.000 |
| Disability | 30.0±5.3 | 16.0±2.3 | 14.82±2.1 | 14.36±2.1 | 0.000 | 28.50±4.6 | 17.75±4.1 | 16.50±3.9 | 16.40±4.1 | 0.000 | 0.33 |

* mean ± standard deviation. ** A significance level less than 0.5. MHPLG: Manual therapy plus H.P. Laser group. MTG: Manual therapy alone group.

The results of the study showed significant differences between Manual therapy plus H.P. Laser and Manual therapy alone groups in terms of pain and disability (p<0.05). There was a significant difference between two groups of study in pain intensity (p<0.05). (Table 5)

**Table-6.** Bonferroni test for pain and disability outcome measures.

| | | | Sig. MHPLG* | Sig. MTG* |
|---|---|---|---|---|
| Pain | Before intervention | Third week | 0.000 | 0.000 |
| | | Sixth week | 0.000 | 0.000 |
| | | two months later | 0.000 | 0.000 |
| | Third week | Sixth week | 0.000 | 0.000 |
| | | two months later | 0.02 | 0.002 |
| | Sixth week | two months later | 1.000 | 1.000 |
| Disability | Before intervention | Third week | 0.000 | 0.000 |
| | | Sixth week | 0.000 | 0.000 |
| | | two months later | 0.000 | 0.000 |
| | Third week | Sixth week | 0.000 | 0.000 |
| | | two months later | 0.000 | 0.000 |
| | Sixth week | two months later | 0.41 | 1.000 |

* A significance level less than 0.05. MHPLG: Manual therapy plus H.P. Laser group. MTG: Manual therapy alone group.

Bonferroni test in two groups showed significant pain changes before the intervention, in third and sixth weeks, and two months after intervention (p<0.05). The disability score was also significant in both groups during the treatment (p<0.05). (Table 6)

**Table 7**- Between group comparison and ANOVA test of pain and disability outcome measures.

| | | Sig * |
|---|---|---|
| Pain | Before intervention | 0.96 |
| | Third week | 0.000 |
| | Sixth week | 0.000 |
| | two months later | 0.000 |
| Disability | Before intervention | 0.34 |
| | Third week | 0.09 |
| | Sixth week | 0.08 |
| | two months later | 0.04 |

* A significance level less than 0.05.

The changes of pain were significant from the third weeks between the groups ($p<0.05$). However, the changes in disability scores was significantly different between two groups only two months after interventions ($p<0.05$). (Table 7)

**Discussion**

Generally, the results indicated that Manual therapy plus H.P. Laser had better effectiveness on muscle activity of the flexor carpi radialis compared than Manual therapy alone. It seems that the increasing tendency in the muscle activity of the flexor carpi radialis muscle continues as long as the patients receive the intervention. The muscle activity evaluation of the flexor carpi radialis showed significant changes in both groups. The decrease of pain and disability were also significant in both groups. But, it seems that Manual therapy plus H.P. Laser is more effective in reducing pain and improving disability compare than Manual therapy alone.

Shady et al. (2021) showed that application of high-intensity laser plus neurodynamic techniques could significantly reduce pain and disability in patients with cervical radiculopathy (21). These results were in favor of the results of the present study, as we identified pain improvement and disability reduction following Manual therapy plus H.P. Laser application. Roy et al. (2018) also compared two types of laser therapy and cervical traction in patients with cervical radiculopathy. The comparison of two groups after interventions revealed significant differences in pain level and disability between the groups. The mean level of pain and disability in the patients at the group of laser plus exercise therapy were higher compared than the patients in group of exercise therapy plus cervical traction (22). The results of this study also would be similar with the results of present study and confirmed pain reduction and disability improvement following Manual therapy plus H.P. Laser application. Haladaj et al. (2017) also found more long-term effects following high-intensity laser therapy compared than traction in reducing pain and improving disability in the patients with cervical radiculopathy. After completion of treatment period, the differences was significant between two groups of study and high-intensity laser could be much long-term effective compared to cervical traction (33). The results of this study also confirmed our results as we obtained better data in reducing pain and improving disability following Manual therapy plus H.P. Laser application.

Although the evaluation two months after treatment accomplishment (follow-up evaluation) did not show a statistical difference in pain and performance variables between two groups, the mean reduction in pain for Manual therapy plus H.P. Laser group was substantially significant compared than the Manual therapy alone. Alayat et al. (2016) revealed that pain reduction and range of motion increase could be higher following high-intensity laser plus exercise therapy application compared than the patients who were under low-intensity laser plus exercise therapy application (33). There were many studies that indicated higher effectiveness following laser application in reducing pain and improving patients' performance. The patients with chronic cervical radiculopathy Manual therapy plus H.P. Laser application lead to reach earlier reduction in pain on initial three weeks of treatment. The inclination of a significant reduction in pain continued during the intervention and also after intervention.

Laser therapy usually changes tissue and cellular function based on wavelength and coherence (34). Absorption of laser waves at the tissue level increases mitochondrial oxidative response and thus increases ATP (35). When the high-intensity laser is used as a pulse shows photomechanical effects (36), which may reduce pain and muscle spasms, and change the level of muscle activity with soft tissue micro-massage. Moreover, photochemical and photo-thermal impacts of high-intensity laser can increase blood flow, vascular permeability, and cellular metabolism. Thus, these phenomena help to improve regeneration of damaged muscle and eliminates painful stimulus. Another hypothesis is that high-intensity laser may activate somatosensory receptors and reduce local pain perception, which may indirectly help to reduce muscle imbalance and improve muscle activity (37). At the tissue

level, laser reduces release rate of histamine and bradykinin from damaged tissues. As a result, laser irradiation helps to reduce sensitivity of pain receptors (38). Moreover, laser therapy diminishes release of substance p from peripheral pain receptors (39) and increase muscle blood flow that leads to reduction in pain, and as a result reduction in ischemia and spasm, and muscle activity improvement (37).

Mendonca et al. (2018) investigated level of muscle activity of the upper trapezius muscle after low-intensity laser therapy. The patients were divided in two groups of low-intensity laser and placebo groups. The results showed significant differences between two groups in muscle activity of trapezius muscle. A significant reduction in amplitude of upper trapezius muscle was also observed after application of low-intensity laser (40). Although low-intensity laser was used in this study and the participants were healthy, which was different from our study, the results showed that laser irradiation could affect level of electrical activity of the muscles. This study also indicated effects of laser irradiation on level of the muscle activity. The authors of present study identified that level of electrical activity in flexor carpi radialis muscle might increase from the beginning of the interventions and were continued throughout the treatment period. It is possible that significant reduction in pain and increasing pain threshold and somatosensory sensation, and also reduction of inflammatory substances leads to improvement of muscle activity. A study by Abdullah et al. (2017) compared two low-intensity laser treatments and Mulligan technique in the patients with unilateral cervical radiculopathy (24). The results revealed that laser irradiation could improve nerve conduction speed and reduce delay time. Accordingly, it can improve the level of muscle activity by improving speed of nerve impulses and reducing delay time. The results of Abdullah study were consistent with the present study. We also observed the positive impacts of Manual therapy plus H.P. Laser irradiation on level of electrical activity of flexor carpi radialis muscle. Although there were no significant differences between two groups of Manual therapy plus H.P. Laser and Manual therapy alone, the table of means showed more changes in muscle activity for the group of Manual therapy plus H.P. Laser application.

## Conclusion

The results of the present study indicated positive effects of Manual therapy plus H.P. Laser application on improving pain and performance and increasing muscle activity of flexor carpi radialis muscle in the patients with chronic cervical radiculopathy. Multimodal treatment can have sooner impacted in reducing pain and disability. Thus, it is recommended to use a high-intensity laser modality for earlier pain reduction in addition to traditional physiotherapy for patients with cervical radiculopathy. It is recommended for the patients with chronic cervical radiculopathy to use combined conservative treatments such as High-Power Laser in their treatment program before surgery.

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## Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

## Conflict of interest

The authors declared no conflict of interest.

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## Graphs

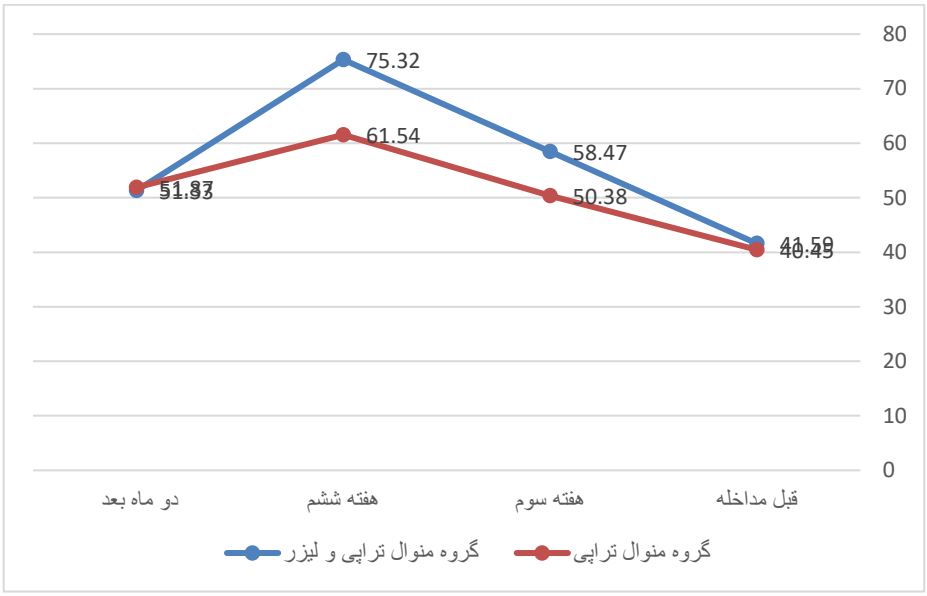


**Fig.2- Flexor Carpi Radialis Muscle Activity**

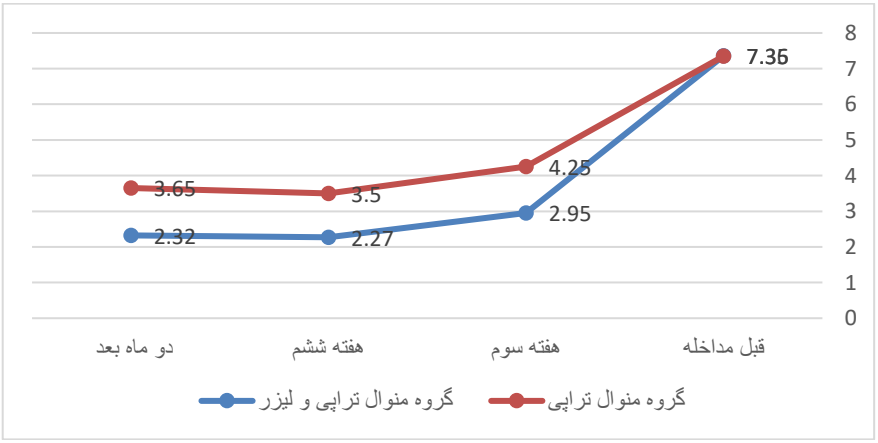


**Fig.3- Pain Intensity**

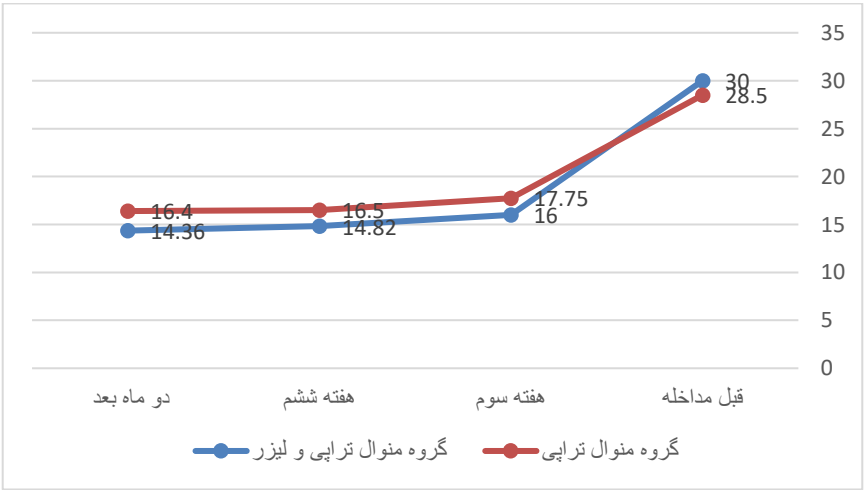


**Fig.4- NDI Score**

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