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Effects of High-Intensity Laser on the Upper Trapezius Muscle Activity in Chronic Cervical Myofascial Pain Syndrome

Abstract

Myofascial Pain Syndrome is the most common musculoskeletal problem that leads to pain, disability, and increased activity of the upper trapezius muscle. The previous studies proposed that the application of lasers could influence pain, function, and muscle activity. Therefore, this study aimed to investigate the effect of high-intensity laser on the upper trapezius muscle activity in Chronic Myofascial Pain Syndrome Patients. In total, 32 patients with chronic Myofascial Pain syndrome were recruited for this double-blind randomized clinical trial. The patients were randomly divided into two groups of High-Intensity Laser and Control group. The High-Intensity Laser group was treated with a High-Power Laser and the Control group received conventional physiotherapy. Overall, muscle activity of the upper trapezius muscle (RMS) was evaluated by surface electromyography device. The pain level was assessed using a Visual Analog Scale and the disability was assessed using Neck Disability Index Questionnaire. Data were analyzed with independent t-tests and paired t-tests ($p<0.05$).
Intergroup comparison indicated significant progress in pain score, disability index, and upper trapezius muscle activity in both groups ($P < 0.05$). The results showed more progress in pain score, disability index, and upper trapezius muscle activity in the High-Intensity Laser group than in the control group ($p<0.05$). The results of this study showed that the application of high-intensity Laser in patients with chronic Myofascial Pain syndrome could effectively reduce pain and improve the disability index. It seems that multimodal intervention can influence signs and symptoms and muscle activity more than conventional physiotherapy alone.

Keywords: *Electromyography, High-Intensity Laser, Myofascial Pain Syndrome, Muscle Activity, Upper Trapezious Muscle.*

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Introduction

Myofascial pain syndrome is the most prevalent musculoskeletal problem, which affects 54% of women and 45% of men (1, 2). Studies have shown that people with chronic myofascial pain syndrome demonstrate metabolic, vascular, and electromyographic changes in this muscle [3,4]. This syndrome has been characterized by the deep and intense pain of skeletal muscles and their fasciae and the presence of over one myofascial trigger point [5]. Clinically, a myofascial trigger point is considered a point of very high excitability in skeletal muscles, which is related to a very tender palpable nodule in a taut band [6]. The myofascial trigger point is a latent ischemic region that explains the cause of pain. This ischemia decreases PH at the trigger point region and creates an acidic environment in the myofascial compartment. It also reduces acetylcholinesterase and increases the effects of acetylcholine, thus resulting in long-term contraction (7).

Myofascial pain syndrome treatments include the inactivation of trigger points, the relaxation of taut bands, and the breaking of the cycles of spasm, ischemia, and pain. The majority of therapeutic methods used for myofascial pain syndrome include therapeutic exercise, non-steroidal inflammatory drugs, superficial and deep heat, electrotherapy, local injection, laser therapy, massage, and dry needling [8, 9,10].

Laser therapy is a non-invasive and painless treatment that can be easily used to treat various disorders in the body [11]. Previous studies have confirmed the use of laser therapy to reduce acute and chronic pains, including rheumatoid arthritis, chronic osteoarthritis, tendonitis, carpal tunnel syndrome, fibromyalgia, knee injuries, shoulder aches, and post-surgery pains [11,12, 13].

Laser therapy creates analgesic effects by inhibiting the sense of pain through different levels and thus causes photochemical changes at cellular levels [13]. At a tissue level, it may reduce the release of histamine and bradykinin from damaged tissues [14]. In addition, laser therapy may also reduce the secretion of the p-substance from the peripheral pain receptors [15]. Laser therapy helps the slow transmission of pain by increasing the delay time, reducing the conduction velocity of the sensory nerves, and blocking A and C-delta nerve fibers [16]. Laser therapy helps reduce pain, inflammation, and the healing process while increasing the lymph and blood processes and the mitochondrial aerobic capacity [17]. Over the past years, High-Intensity Laser Therapy has become common in physiotherapy. The difference between low- and high-intensity lasers is the power used [18].

Many studies, including the study of Alayat et al. (2014), which was conducted on patients with chronic back pain and examined the long-term effect of high-power lasers on these patients (19), and the study of Fiore et al.in 2011, which examined the short-term effects of high-power laser and ultrasound compared in back pain patients (20) and also Dundar et al. (2015) investigated the effect of high power laser in female patients with trapezius muscle myofascial pain syndrome (21) and Alayat et al. (2016) investigated the effect of high power laser on chronic neck pain patients. All of these studies showed the positive effect of high-power lasers in reducing pain and disability in patients with different problems (22). Taheri et al. (2016) compared the effects of shockwaves and lasers in reducing patients' symptoms of myofascial pain syndrome in the upper trapezius muscle. They found that both treatments had a similar effect on the pain in the long term and helped remove the symptoms in patients with myofascial pain [23]. All these studies showed the positive effect of high-intensity lasers in reducing pain and disability in patients with different problems (19-22).

Overall, the results of the relevant studies suggested that lasers could be effective in neck pain. However, unlike non-specific neck pain, a number of studies that have examined the effects of laser on specific cervical pain, including myofascial pain syndrome, are limited. In addition to the few numbers of studies, it is difficult to conclude the effectiveness of laser in patients with myofascial pain syndrome due to the low quality of studies and variations in methods. It indicates that the clinicians need to conduct more studies in this field. Thus, the present study aimed to investigate the effect of high-intensity lasers on the upper trapezius muscle activity in Chronic Myofascial Pain Syndrome Patients.

Method

This study was a double-blind randomized controlled trial. Thirty-two patients with chronic cervical myofascial pain syndrome voluntarily participated in this study. The patients were divided into two groups by simple non-probability sampling method. The medical ethics committee at the Zahedan University of Medical Sciences (ZUMS) approved the study ethics and issued the ethics certification number as #IR.ZAUMS.REC.1401.109. It was also registered with the region's Clinical Trials Registry (IRCT20220626055278N1). All participants signed a written informed consent form before starting the trial.

Inclusion Criteria

Inclusion criteria included women aged between 18 and 55 years, with chronic cervical myofascial pain syndrome, an active trigger point in the upper trapezius muscle, five major criteria as suggested by Simon's Diagnosis methods, and at least one of the three minor clinical diagnosis criteria of the cervical myofascial pain syndrome [24], Cervical disability index percentage from 10 to 40%, Pain visual index of more than or equal to 3. No history of fracture or structural abnormalities, no history of dizziness and head trauma. Also, the patients had no history of progressive rheumatic or neurological diseases, long-term use of corticosteroids, accident, whiplash injury, malignancy, or pregnancy.

Exclusion Criteria

Exclusion criteria included pain or inflammation in the neck, receiving other treatment during the research, unwillingness to continue treatment, incomplete treatment, taking painkillers, and using sedatives or alcohol 48 hours before the starting time.

The sample size was determined based on a pilot study. Ten patients with the inclusion criteria were divided randomly into two equal groups, and the main part of the study was conducted on them. The means and SDs for the parameters from this pilot study, with $\alpha = 0.05$ and 90% power were applied 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 study and the formula stated, the sample size in each group was 16 patients.

The sampling method was the simple, non-probabilistic sampling method, and from the available population. The participants will then be allocated randomly to two intervention groups, the group under High-Intensity Laser and the control group under routine physiotherapy alone. Randomization would be performed using a random number sequence. The patients were not informed about the basics of the study. The administrator and participants were informed about the grouping data. However, the physiotherapist who evaluated the patients, measured the outcomes, and analyzed the data was blinded about the groups.

Procedure

The initial clinical examinations were performed by demographic information, MRI report, patient history, and five major criteria as suggested by Simon's Diagnosis methods and at least one of the three minor clinical diagnosis criteria of the cervical myofascial pain syndrome [24]. Then, the patients were selected to enter the study by examining the inclusion and exclusion criteria.

Pain intensity: The VAS (Visual Analogue Scale) of the McGill Short Questionnaire was used to evaluate the intensity of pain (25). The VAS is a 100-mm, 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: The Neck Disability Index Questionnaire was used to obtain the neck disability level of the patients. A score of zero in this questionnaire indicates a lack of problems and as this score goes up, it indicates an increase in disability level (26).

Muscle Activity Measure: As suggested by guidelines [27], the electromyography device (Bio Graph infiniti, 2180 Belgrave Avenue, Montreal, QC H4A 2L8 Canada) was used to record muscular activity. The patient was placed on the chair so that the hip and knee were at 90 degrees and the soles of the feet were on the floor. The patient's neck and shoulder were exposed and completely cleaned and disinfected with alcohol, and then the electrode was placed on the upper trapezius muscle. To place the electrode on the upper trapezius, the shoulder was at 90 deg. abduction. The electrodes were placed parallel to the fibers of the trapezius muscle (midway between the spinous process of the seventh cervical vertebra and the acromion process).

To avoid noise in signals recorded, automatic filtering by the device was used. To reduce environmental noises, the Band Bass Filter that filters below 10 Hz and above 50 Hz was used [28].

To take the maximum contraction, an individual performed the scapular elevation or shoulder shrug with a relevant weight in a standing position. The amount of the relevant weight for each individual was determined by a hand-held dynamometer [29]. The maximal isometric contraction was performed in the form of three 5-second contractions with a 1-minute interval between each contraction [30].

To record functional RMS, the patients were asked to perform the 90° abduction in a sitting position on a scapular plane. The motion was performed in three 5-second repetitions [31].

This task was repeated 3 times and the patient was allowed to have a 2-minute break between two tasks to avoid fatigue.

Muscle activity was normalized using the following formula:

$$\text{Muscle activity level} = \text{RMS}/\text{MVC} \times 100$$

Intervention

The patients were randomly divided into two groups: The high-intensity Laser group and the control group. The patients in both groups received routine physiotherapy treatment including TENS (burst, 20 min), US (Continuous, 1Hz, 5 min), Ischemic Pressure (60 sec), and hot pack (20 min) (17).

In the High-Intensity group, a High-Intensity Laser instrument with the wavelengths of 660, 800, 905, and 970 nm (Model K-LASER, Class IV, made in Italy) was applied with the probe held at 90° angle, noncontact and pulse and continuous mode. The High-Intensity 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 (32).

The patients were treated in 12 sessions three days a week for four weeks (32). All the variables were measured before and after the intervention.

Data Analysis

The results were presented as mean values and standard deviations (SD). The criterion of significance 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 evaluated using Levene's test. The paired and independent t-tests were used for within- and between-group comparisons.

Results

Fifty-seven people were nominated for this study and 40 of these patients were divided into two groups: The high-intensity Laser group and the control group (Fig-1). Figure 1 presents the recruitment strategy and experimental plan. The pilot study showed that 20 subjects would be needed for each group (a total of 44 subjects). Ultimately, 32 subjects finished the study procedure. Eight of them were not eligible based on the inclusion and exclusion criteria. Four subjects from the Control group and four subjects from the H.P. Laser group left the study because of personal problems, unwillingness to continue treatment, incomplete treatment, or reasons unrelated to the investigation. The flowchart of choosing participants in the study is shown in Figure 1.

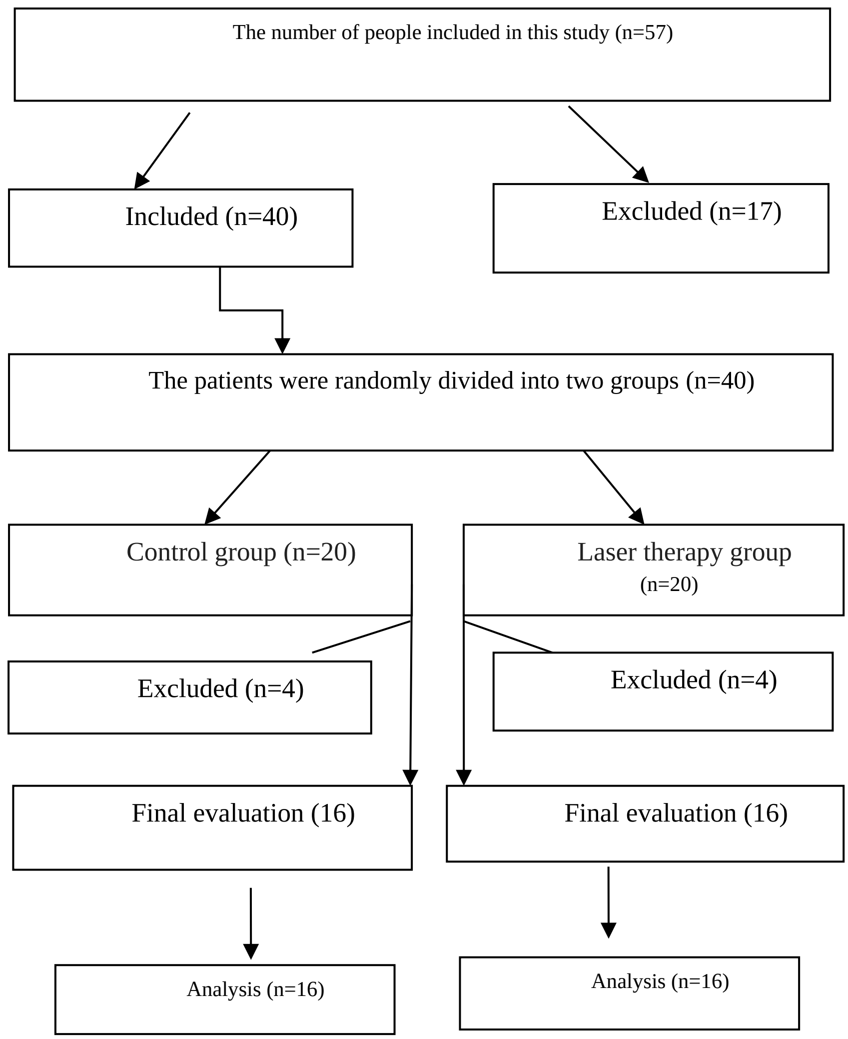

Fig-1: Flow diagram of study selection.

Data were analyzed by SPSS 27 software. The normality of data distribution was examined by the Shapiro-Wilk test. The p-value was considered as less than 0.05. Thus, the statistical tests did not reject the hypothesis of normality and the data was normal ($p>0.05$).

Table 1 gives patients' demographic data, including age, height, weight, and body mass index (BMI). Patients' demographic characteristics, which had been recorded before the treatment, were compared between the two groups. There was no difference between the two groups in terms of these variables (Table 1).

Table 1: Comparison of demographic characteristics of the two groups

Variables	High-Intensity Laser Group *	Control Group *	Sig. **
Age (year)	32.7 ± 11.3	33.6 ± 10.3	0.83
Weight (Kg)	70.2 ± 9.9	68.0 ± 7.2	0.52
Height (m)	166.5 ± 6.2	166.3 ± 5.3	0.94
BMI (Square meter/kg)	25.2 ± 1.8	24.5 ± 1.2	0.25

*Data are in standard deviation ± means

** Significance is less than 0.05

For the intra-group result comparison, the paired-t test was used as given in Table 2.

Table 2: Intra-group comparison before and after the intervention in the two groups

	High-intensity laser group (16 patients)			**Routine group (16 patients)**		
Variables	**Before**	**After**	**Sig ***	**Before**	**After**	**Sig ***
Pain	5.9 ± 1.4	1.7 ± 0.7	0.000	6.14± 1.2	2.93 ± 0.8	0.000
Disability index	27.8 ± 3.2	13.4 ± 2.5	0.000	28.1 ± 3.7	18.86 ± 2.7	0.000
Activity of muscle	76.0± 30.8	57.5 ± 20.4	0.000	80.8 ± 15	76.1 ± 14.6	0.000

* Significance less than 0.05.

Table 2 results are as follows:

Pain in both groups significantly decreased. In the high-intensity group, pain decreased from 5.9±1.4 to 1.7±0.7, while in the control group, pain decreased from 6.14±1.2 to 2.93±0.8, with the changes seeing a significant rate (P=0.000).

The disability index in both groups also saw a significant reduction. In the high-intensity laser group, disability decreased from 5.9±1.4 to 1.7±0.7, while in the control group, disability decreased from 6.4±1.2 to 2.3±0.8, with the changes being significant (P=0.000).

The activity of the muscle saw a significant reduction in both groups. In the high-intensity laser group, the activity of the muscle in the functional state reduced from 76.7±30.8 to 57.5±20.4, while in the control group, the activity decreased from 80.8±15 to 76.1±14.6, with the changes experiencing a significant trend (P=0.000).

For the inter-group comparison, an independent t-test was used, and the results are given in Table 3. To determine whether the randomization process is true or not, before the study, data were compared. The results suggested no difference between the two groups in terms of the studied variables before the treatment (P=0.05).

Table 3: Comparison of the results before the intervention between the two groups

Variable	**High-intensity laser group**	**Control group**	**Sig. ***
	Before the intervention		
Pain	5.9 ± 1.4	6.1± 1.2	0.67
Disability	27.8 ± 3.2	28.1 ± 3.7	0.83
Activity of muscle	76.7± 30.8	80.8 ±15.0	0.65
	After the intervention		
Pain	1.7 ± 0.7	2.9 ± 0.8	0.000

Disability	13.14 ± 2.5	18.8 ± 2.7	0.000
Activity of muscle	57.5 ± 20.4	76.13 ± 14.6	0.01

* Significance less than 0.05.

Table 3 results are as follows:

Pain in the two groups was significantly different. In the high-intensity laser group, the pain value was 1.7±0.7, while in the control group, the pain value was 2.9±0.8. This difference was significant (P=0.000).

The disability index was also significantly different in the two groups. In the High-Intensity laser group, it was 13.14±2.5, while in the control group, it was 18.8±2.7. This difference was significant (P=0.000).

Muscle activity in function also saw a significant difference. In the High-Intensity Laser group, it was 57.5±20.4, while in the control group, the same activity rate was 76.13±14.6, with the difference being significant (P=0.01).

Discussion

The results of this study showed that changes in upper trapezius muscle activity, intensity of pain, and disability index were statistically significant after intervention in both groups. Also, the mean of changes in muscle activity, intensity of pain, and disability score in the High-Intensity Laser group was more than the control group. Generally, it seems that High-Intensity Laser can be more effective in reducing Muscle activity and pain and improving disability compared to conventional physiotherapy.

In laser therapy, such factors as wavelengths, frequency, treatment duration, and power were found to reduce pain and inflammation and improve healing [12]. Laser therapy usually changes tissues and cellular functionality based on wavelengths and coherence [33,34]. When used as a pulse, high-intensity laser features photomechanical effects [35], which may relax muscles with spasms by micro-massaging the soft tissues. Post-laser therapy pain reduction could be due to increased micro-circulation, immunological process stimulation, and nerve regeneration [36]. It is hypothesized that the application of high-intensity laser on myofascial trigger points can help transport some photothermal energy to deeper tissues and resolve the energy crisis near the trigger points [21]. The laser-induced increase in the blood flow of the muscle helps reduce pain and reduce spasm and ischemia, with the myofascial pain syndrome treatment, which is the breaking of pain, spasm, and ischemic cycles, will be satisfied [21].

Mendonca et al. (2018) concluded a significant reduction in the amplitude of the upper trapezius muscle of healthy people at the 30% level of the voluntary maximum contraction, following the application of the low-intensity laser [37]. Although low-intensity laser was used in this study and the participants were healthy, the results showed that laser irradiation could affect the level of electrical activity of the muscles. It is possible, that a reduction in pain and increasing pain threshold and somatosensory sensation, and also reduction of inflammatory substances leads to improvement of muscle activity (37). Nazari et al. (2019) did a study on patients with knee osteoarthritis, who were assigned to three groups 1) high-intensity group; 2) conventional physiotherapy, and 3) exercise therapy for twelve sessions. The high-intensity laser group saw a significant reduction of pain, an increase in the range of flexion, and an improvement in knee performance compared to the other two groups. The results of this study also would be similar to the results of the present study and confirmed improvement in pain and disability following High-Intensity Laser application [38]. A review study by Ezzatii et al. (2020) demonstrated the positive effects of high-intensity lasers in musculoskeletal injuries [39]. A study by Abdullah et al. (2017) compared two low-intensity laser treatments and the Mulligan technique in patients with unilateral cervical radiculopathy (40). 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 the speed of nerve impulses and reducing delay time. The results of Abdullah's study were consistent with the present study. We also observed the positive impacts of High-Intensity lasers on the level of electrical activity of the flexor carpi radialis muscle. There were significant differences between the two groups in upper trapezius muscle activity. The table of means showed more changes in muscle activity for the group of High-Intensity Laser applications. Another study by Ordahan et al. (2018) showed that the high-intensity laser group had greater significant effects than the low-intensity group in patients with Plantar Fasciitis. The findings of the present study were found to be consistent with those of this study, despite the differences in power, wavelength, place of treatment, and combined therapies [41]. Kydok et al. (2020) found that the high-intensity group a significant improvement in the grip power, shoulder, arm, and hand disability questionnaire, quality of life scale, and the sf-36 questionnaire, compared to the low-intensity group in patients with lateral epicondylitis [42]. In all studies above, pain is reduced after the direct application of high-intensity laser on nerves the indirect increase of blood flow, and the increase in vascular permeability and cellular metabolism. As stated, laser therapy was found to be more effective than conventional physiotherapy in patients with myofascial pain syndrome, which may be due to the physiological, chemical, and mechanical effects (41,42).

Conclusion

This study revealed the advantage of combined high-intensity laser and conventional physiotherapy treatment on the variables of pain, disability, and muscle activity compared to the conventional physiotherapy treatment alone, among patients with cervical myofascial pain syndrome. Therefore, myofascial pain syndrome should be treated with a combination of conventional physiotherapy and high-intensity laser, although the application of high-intensity laser depends on wavelengths, power the total energy received by tissues, and the number of treatment sessions.

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Authors' Contributions:

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

Conflict of interest

The authors declared no conflict of interest.

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